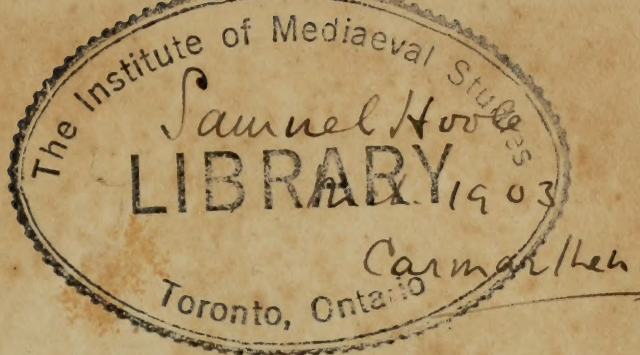
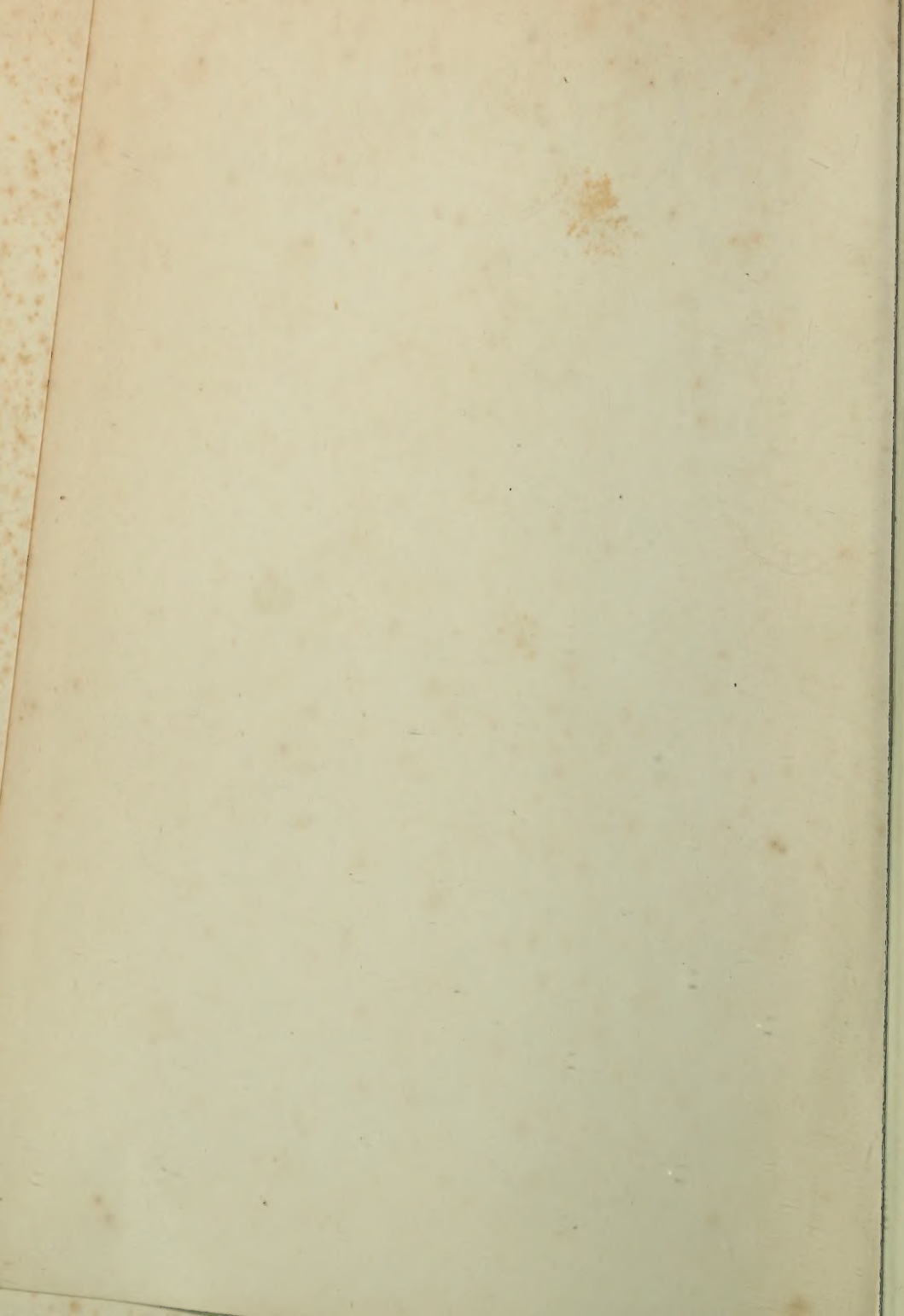
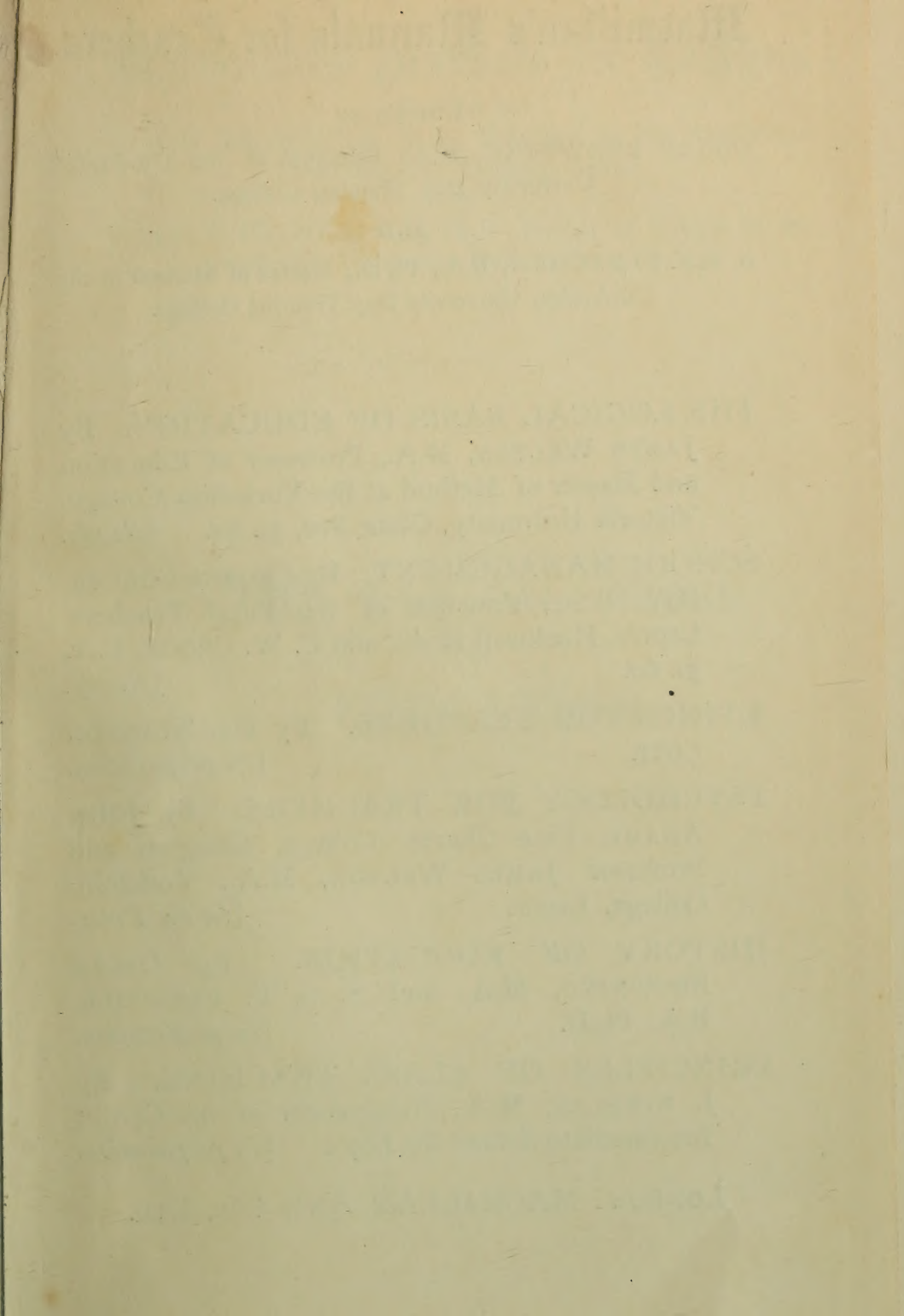


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OSCAR BROWNING, M.A., Principal of the Cambridge
University Day Training College.

AND

S. S. F. FLETCHER, B.A., Ph.D., Master of Method in the
Cambridge University Day Training College.

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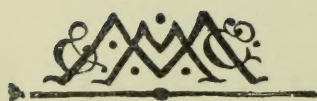
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THE LOGICAL BASES OF EDUCATION



THE LOGICAL BASES OF EDUCATION

BY

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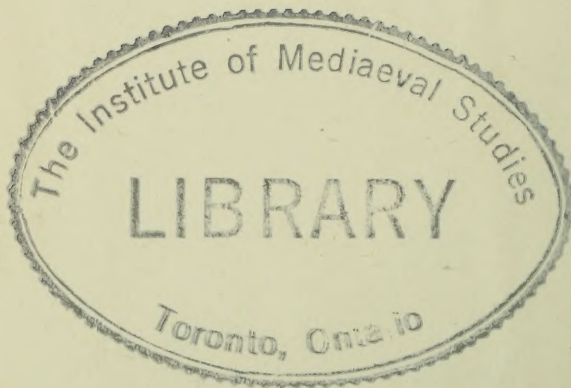
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PREFACE

THE aim of this book is to set forth the rational bases of all true educational work. It is believed that such bases can only be found in those modern developments of logical theory which have marked the latter half of this century. Hence, but little of the traditional formal logic will be found in the book. As a mental discipline I believe that formal logic has considerable value, but it seems to me certain that we cannot find foundations for modern education in a logical theory developed under a conception of knowledge very different from that of the present day.

After the whole of the present book was planned, and much of it written, I read in an interesting "Review of Educational Currents of Thought in 1895 in Central Europe," published in the *Report of the Commissioner of Education*, 1896-7, issued by the Central Bureau of Education in the United States of America, a passage which so exactly ex-

presses the conception under which I was writing, that I venture to quote it: "Logic . . . aims at the development of a view by which the world of phenomena can be actually understood and the truth found. It endeavours to prove that by proper perception, consideration, and comparative observation, by an arrangement and adjustment under definitions (consequently by critical judgment and conclusion), and by convincing argument and reliable development of a scientific system (by means of continued and strict induction, deduction, and classification) science originates, and a proper view of the world can be gained and made perceptible.

"Such a logic will show how the growing human being must be directed so that the physical and psychical germs of possibilities of a later development within him may grow towards perfection, and that his whole earthly existence may present the realization of ethical and æsthetic ideals. It therefore points out the course to be pursued by individual training, and outlines the duties of social education, which, in its ultimate aims, is more definitely defined by ethics. It is the duty of the teacher, therefore, to see that upon the foundation of the original work of the expounders of this science, a logic be prepared in which all useless ballast from formal logic . . . is omitted, and a scientific methodology (induction, deduction, &c.), be founded on the basis of the qualities

and laws of human thought which have been made objects of perception by psychology. Upon the basis of such a logic alone can pedagogy establish the laws of intellectual education and found a pedagogical methodology" (vol. i., p. 133).

My experience with the students of the Department for the Training of Teachers at the Yorkshire College for the last eight years has convinced me that such a treatment of logic appeals to them as both helpful and interesting, especially if its reality is brought home by the analysis of actual specimens of human reasoning such as are given as Exercises at the end of this book.

In such a work as this it would be pedantic to attempt to mention all the logicians from whose writings I have derived inspiration and suggestion, but I cannot refrain from expressing my special obligations to Dr. Bosanquet, Dr. Bradley, and Mr. Hobhouse. My thanks are due to Mr. W. P. Welpton, Lecturer on Education at the York Training College, for his kindness in reading certain portions of the book in manuscript and the whole of it in proof, and suggesting various improvements.

J. W.

LEEDS,
June, 1899.

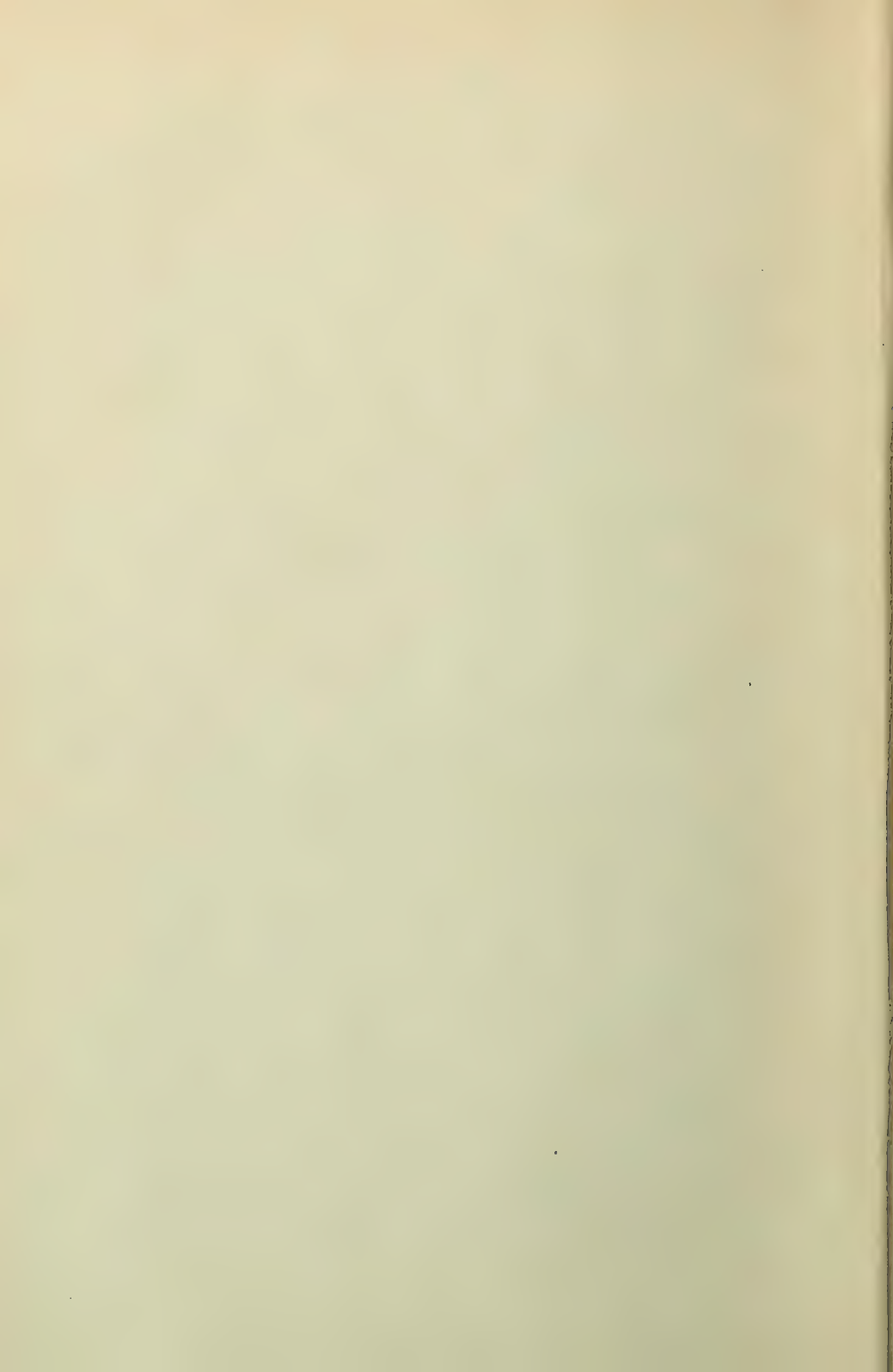


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THE LOGICAL BASES OF EDUCATION.

CHAPTER I

GENERAL NATURE OF KNOWLEDGE

§ 1.—Bacon begins one of the best-known of his essays with the words: “‘What is truth?’ said jesting Pilate; and would not stay for an answer.” Whether or not this is a libel on the Roman procurator, it certainly represents a mental attitude which cannot be adopted by the educator. One of the main parts of his work is teaching. And teaching has a two-fold aspect—on the one hand it regards the pupil, and on the other it regards the subject taught. Between these two it tries to establish the relation we call knowledge. The aim of teaching is, then, to lead the pupil to attain knowledge, and to develop in him the power of using and extending that knowledge.

Education
and
Knowledge.

§ 2.—Now, if we ask ourselves what we mean by ‘knowledge’ we can find no other answer than that

Knowledge
and Truth.

it is that part of human thought which is proved true. And human thought is true just so far as it agrees with the facts of the world. All knowledge is, then, a grasp of truth. Not indeed of the whole truth: that we do not know, and never shall know. For the whole truth is the totality of reality or existence; in other words, the universe. As this is infinite it can never be grasped by the finite human intelligence. But, as generations succeed each other, knowledge advances. Taking each new position as a fresh starting point, man uses the knowledge he has acquired as a key to unlock fresh mysteries. What was so wonderful to our forefathers that it could only be accounted for by the assumption of supernatural agency is regarded by us as commonplace. Thus the bounds of superstition are continually contracted. For superstition has play only where knowledge is absent and fancy takes its place. As Mr. Clodd remarks, "magic rules the life of the savage,"¹ whilst the life of civilized man tends to become more and more completely ruled by a rational conception of law and system.

Knowledge
and
Supersti-
tion.

§ 3.—The thought of the modern civilized European is then, especially at first sight, very different from that of the savage. But this must not blind us to the fact that there is continuity between them; that the former has been evolved slowly and with difficulty from the latter. "The low intellectual environment of man's barbaric past was constant in his history for thousands of years."² It was only when man began to think and enquire, as well as to feel and fancy, that knowledge began to take the place of belief in magic, in charms, in fairies, and in all the other apparatus by which savage man attempts to explain

¹ *Tom Tit Tot*, p. 54.

² Clodd, *op. cit.*, p. 106.

the phenomena he sees about him. For modern Europe this birth of thought took place in Greece less than three thousand years ago. Since then there has been gradual advance, not however without long periods of stagnation, and even of retrogression. We need not go back very far to find superstition governing most of the life of the majority of Englishmen. King James I. believed firmly in magic, and in his book on *Dæmonology*, he speaks of the "devil teaching how to make pictures of wax or clay, that by roasting thereof the persons that they bear the name of may be continually melted or dried away by sickness." And James was "the British Solomon." Indeed, we need not leave our own day to find many examples of the truth that whenever knowledge is absent superstition reigns. The thorough-going conception of the universality of natural law exists amongst comparatively few even in our own day. "Scratch the epiderm of the civilized man, and the barbarian is found in the derm" says Mr. Clodd with undeniable truth. "In proof of which," he goes on, "there are more people who believe in Zadkiel's *Vox Stellarum* than in the *Nautical Almanac*; and rare are the households where the *Book of Dreams* and *Fortune-Teller* are not to be found in the kitchen."¹ And again: "As many a stable-door and mainmast testify, the nailing of horse shoes to 'keep off the pixies,' and, conversely, to bring luck to farmer and sailor, thrives to this day."² Many other examples are given by Mr. Clodd in the very interesting book from which we have quoted, and doubtless, every reader will be able to furnish additional instances. But enough has been said to illustrate the point that the outcome of ignorance is superstition.

Now, it should be noted that superstitions have

¹ *Op. cit.*, p. 97.

² *Ibid.*, p. 34.

their origin mainly in man's feelings and emotions, and especially in the emotion of fear, for the unknown generally inspires terror in a mind that has little or no conception of natural law. But superstitions are not merely mental errors, they have a practical bearing, for, in so far as they are believed, they determine conduct.

Further, what has been said has made it evident that the only cure for superstition is increased knowledge. And this has a deep interest for the educator; for, to again quote Mr. Clodd, "the art of life largely consists in that control of the emotions, and that diversion of them into wholesome channels, which the intellect, braced with the latest knowledge and with freedom in the application of it, can alone effect."¹

Knowledge
and Belief.

§ 4.—The above remarks have brought into prominence several important points which we shall do well to consider. In the first place we see that all belief is not knowledge. Belief is unquestioning acceptance by the mind. But the savage believes as firmly in various forms of magic as the civilized man does in the law of gravitation. And his beliefs influence his actions. "The Basuto avoids the river-bank, lest, as his shadow falls on the water, a crocodile may seize it, and harm the owner . . . the Arabs believe that if a hyena treads on a shadow, it deprives the man of the power of speech."² Now it may seem strange that such beliefs have been able to survive for so many generations the continual contradictions they must have received from experience. Indeed, this would be inexplicable were it not for another piece of experience—the fact of the marked conservatism which human nature shows with regard to its beliefs. Prejudice is an enormous

¹ *Op. cit.*, p. 109.

² *Ibid.*, pp. 79—80.

force in human life, and not less potent is that mental inertia which makes it hard for men to strike out a new line of thought for themselves. "It is not error," wrote Turgot, "which opposes the progress of truth; it is indolence, obstinacy, the spirit of routine, everything that favours inaction."¹ It is only when this mental indolence is overcome, when the spirit of enquiry is roused, that men begin to ask why they believe this or that, and according to the answer to retain or reject the belief.

This leads us to see both the difference and the connexion between belief and knowledge. So far as the mental state of any individual is concerned, belief and knowledge are so far alike that both are states of full assurance of the truth of the matter in question. But they differ in this—that in the case of knowledge alone this assurance can be shown to be justified by evidence other than itself. For example a savage believes that an earthquake is the mark of the anger of some supernatural being with those who suffer its effects, but he can bring forward no evidence outside the earthquake itself to support his belief. On the other hand, the modern scientific man can show by unimpeachable evidence that the earthquake is the result of natural laws and is itself an expression of the orderly working of the universe. In thus relating the earthquake to other physical events he has replaced what was mere belief by knowledge.

There is a further and most important distinction. Belief is always an individual act. Any number of persons may, indeed, agree in believing the same thing, and this we loosely call "sharing a belief" or "holding a common faith." But the belief is not common if we use our words strictly. What is

¹ Quoted by Mr. Clodd, *op. cit.*, p. 108.

common is the object of belief: each man believes for himself, each man feels his own full assurance. And this assurance he cannot communicate to another. The utmost he can do is to influence the mind of him whom he wishes to convert so as to incline him to accept the same object of belief. Belief is then, in its very essence, particular; that is, it is the state of some one individual mind. Knowledge, on the other hand, is universal; that is, it is common to any number of minds. This is because knowledge is, as has been already said, a grasp of truth, or, as we may put it in other words, an insight into some portion of reality. It follows that knowledge is not dependent on any one individual mind, for neither the belief nor the thought of any individual can alter an element of the real world. It is true that knowledge is increased by the work of individual minds. But once a piece of knowledge is arrived at it can be communicated to others and made common property. This is so because the evidence which establishes every piece of knowledge can be made clear. Of course, when a piece of knowledge is grasped by an individual mind, it is believed, and it becomes part of the contents of that mind; the act of knowing is thus individual. But whilst belief is nothing beyond the act of believing, knowledge is not the mere act of knowing. For nothing is knowledge which is not based on evidence sufficient to prove it, that is, which is not shown to be part of the order of the world. Any mind which can appreciate this evidence is forced to accept the piece of knowledge which is thus substantiated. Hence, all knowledge is in its very essence universal in its nature; for all minds which can understand it must accept it as something not merely believed but

as actually proved, and therefore known to be true.

This fact that all knowledge is of the truth, whilst belief is frequently of the false, leads us to see that the general conditions of knowledge are independent of individual beliefs. Men have, indeed, often believed they possessed knowledge when future advances have shown that their supposed knowledge was imperfect or even false. Such a mistake is easily understood when it is borne in mind that to the individual both knowledge and belief are states of full assurance; that all knowledge is belief, though all belief is not knowledge. It is easy, then, for a man to deceive himself as to the extent to which his beliefs are really supported by sufficient evidence, and especially so since even his power to appreciate the weight of evidence is partly dependent on the amount of his knowledge. He may, then, easily confuse considerations which appeal to his prejudices and agree with his beliefs with true evidence which appeals only to his reason. Such considerations help us to see that whenever what is not true has been mistaken for knowledge the reason has been that the real conditions of knowing have been departed from. When these conditions are really fulfilled, knowledge results. It will be our task in this book to examine the nature of these conditions.

§ 5—A second point brought out by the comparison of the thought of savages with that of civilized man is that at all times man tries to find some explanation of the world in which he lives. At every moment of his life he is brought into contact with objects and phenomena over which his wishes and feelings and thoughts have no control. The storm comes and sweeps away his hut, the sun rises and sets, the moon waxes and wanes, the clouds gather and

Savage
Philosophy.

disappear. Or again, his own actions frequently have results which he neither foresees nor desires. He eats a new berry and is ill. He steps on a stone in climbing a hill; it gives way under him, he falls and is injured. Even consequences which he can foresee, in many cases he cannot prevent. He fails to find water and suffers thirst; he is overtaken by the prairie fire and is burnt.

Thus even at the lowest stage of development man cannot help finding himself in the midst of a world of which he forms a part, but which exists independently of him. But the savage has not in the strict sense of the word begun to think. He is too fully occupied in keeping himself alive to concern himself with anything which has not a direct personal bearing. Especially must he be continually on guard against agencies that may work him ill. He is always finding new sources of evil to himself, and he is inclined to suspect the unknown. Savage man thus never looks at his world as a whole. For him it consists of isolated things and events which have a bearing—generally evil—on his own life and his own comfort. The most obvious explanation which occurs to him is to attribute to all things those powers of life which he himself possesses. Every thing is alive, or is at least the abode of a living spirit, generally of a malignant nature. Hence arises that general belief in magic which marks all races of savages.

So, too, savage man has not learnt to distinguish between realities and symbols. Nothing is connected with a man more uniformly than his shadow; hence it is believed that a man may be injured by doing to his shadow what would injure the man if done to himself. Similarly a man's name is believed to be an integral part of himself, and it is a

universal belief amongst savages that if an enemy knows a man's name he has him in his power. Consequently, in many tribes the real names are kept secret and every individual is known by a nickname.

These few examples warn us against expecting to find any consistency in the philosophy of the savage. He attempts to explain his world not as a whole but piece by piece. He has hardly indeed begun even to ask himself what these separate objects of his experience are ; of their real properties he is profoundly ignorant. Still, he has begun to see, though most dimly, that there are relations between things. It is true that the only relations he finds his attempts at explanation upon are those of striking, but often very superficial, resemblance. Yet it is in this vague and fragmentary recognition of relations that science has its root.

§ 6.—As man begins slowly to emerge from savagery less and less of his time and energy is occupied with the mere preservation of his life. So he begins to find time to feel curiosity about those things which do not immediately affect him, and even about the world as a whole. But the influence of the traditional beliefs remains strong. He still regards himself as the centre of the universe, the being for whose benefit sun, moon, stars and earth were made. Consistently with this he still thinks of 'things'—*i.e.* material objects which can affect him through his senses—as independent pieces of reality whose nature is not affected by the relations in which they stand to each other. In other words, he regards the world as a sum of things whose relations with each other are accidental. From this point of view 'things' are units of existence which can be re-arranged in any way, like a set

Explan-
ation of the
World as
a Sum of
Things.

of ninepins or a group of billiard balls, without altering their nature.

Within such a philosophy there is still abundant room for magic and supernatural agencies. For whilst the relations between things are regarded as indifferent and variable in any way without affecting the nature of the things related, it is obvious that those relations will not be carefully investigated, and the analogy of a living agent will still be continually called in to explain occurrences which are not understood. So fairies and witches remain part of the machinery of the world, and means must be taken to guard against their evil influence. Hence the survival of the use of charms, which is still extremely common amongst the majority of the people of Western Europe. "Many a fragment of cabalistic writing is cherished and concealed about their persons by the rustics of Western Europe as safeguards against black magic."¹

Again, so long as the relations of things are not regarded as important to the constitution of reality, and so remain unstudied, relations of striking likeness will continue to exercise undue influence over man's attempts at explanation. Thus, "doctors in the seventeenth century...with...perchance unconscious humour, gave their patients pulverized mummy to prolong their years. 'Mummie,' says Sir Thomas Browne, 'is become merchandise. Mizraim cures wounds, and Pharaoh is sold for balsams.'"² Even in the present day "in Suffolk and other parts of these islands, a common remedy for warts is to secretly pierce a snail or 'dodman' with a gooseberry-bush thorn, rub the snail on the wart, and then bury it, so that, as it decays, the wart may wither

¹ Clodd, *op. cit.*, pp. 214—215.

² *Ibid.*, pp. 62—63.

away.”¹ This is quite on a level with the action of the Cherokee Indians when “to ensure a fine voice, they boil crickets and drink the liquor.”²

§ 7.—Insufficient as is the explanation of the world which sees in it only a sum of things which may enter into any relations with each other without affecting their own nature, it yet satisfied the mind of man till a few centuries ago. It was only with the birth of modern physical science that men really began to appreciate the importance of relations in the constitution of the world. But the old view of the independence of things still remains the philosophy of all the uneducated—that is, of all young children and of the great majority of adults. And it is from that view the educator must start in leading his pupils to a truer conception of the world. In this respect, as in so many others, the child epitomizes the evolution of the race.

Explana-
tion of the
World by
Laws.

It may be said, then, that modern science began with the discovery that the nature of things is affected by their relations. And this discovery was the necessary result of a deeper study of things themselves. Even to a superficial observation it was evident that many things change according to the relations in which they are placed. The clouds are scattered by the wind, the snow melts in the sun. With other things, indeed, the case seemed different, and in nothing was stability more apparent than in “the everlasting hills.” But closer observation showed that even these changed continuously. Rain and frost, torrent and glacier were always at work, and their effects could be seen by the careful watcher. Thus, the idea that change is the characteristic of all things, and not a mere accident to some, began to take firmer and firmer hold of men’s

¹ *Op. cit.*, p. 62.

² *Ibid.*

minds, though doubtless it was long before the stage was reached which is expressed in Tennyson's lines,

"The hills are shadows and they flow
From form to form and nothing stands ;
They melt like mist, the solid lands,
'Like clouds they shape themselves and go !'"¹

Factors of
Change.

But change implies an agency which causes the change. Either this agency is to be found in the nature of the thing itself, in some other thing in active relation to it, or in a combination of the two. Now, the agency of things from without is in many cases obvious. Trees and land are washed away by a torrent, smiling fields and prosperous cities are overwhelmed by a volcanic eruption, fire burns and water drowns. Hence, agency from without has seemed to some a sufficient explanation of all change. In this too we find the survival of the older belief, though under a new aspect. The older belief regarded things as essentially stable, and all change as accidental and exceptional to the general order. When change was observed it was attributed to external agency. The newer view was in opposition to this in regarding change as the normal state, but it agreed with it in attributing all change to outside agency, though the agency sought was that of material things instead of that of supernatural beings and unknown powers.

Such a view, however, cannot survive deeper critical examination. External influences are soon seen not to be the only determining factors. An acorn and a grain of corn may be planted side by side and exposed to the same influences of soil and weather, but the one will develop into an ear of corn and the other into an oak tree. It is true that

¹ *In Memoriam*, cxxiii.

neither will develop at all apart from appropriate conditions of soil and climate, and so their development is determined by those external conditions. But it is equally clear that, given the conditions, the development which actually takes place is determined by the thing's own nature. And this nature is the essence of the thing itself. Grains of corn buried with the Pharaohs for thousands of years have been sown, and have borne fruit. External conditions are, then, contributing factors in development, but they alone do not determine the nature of that development.

In the animal world the same thing is yet more manifest. An animal is much more independent of external conditions than is a plant, for by changing his locality he may seek conditions which suit him. To the extent to which he can do this he determines his conditions rather than is determined by them. Doubtless the latter factor in his life is not absent, and in the course of ages may profoundly modify his constitution. But the mere influence of surroundings will not account for the whole of animal life.

In the highest degree of all is this self-determination seen in man, who, by the exercise of his reason and will, can modify his environment in all kinds of ways. What a man does and becomes is, of course, influenced by circumstances external to himself, and that often in a very great degree. But his conduct and life are not absolutely determined by those circumstances, but are regulated by the man's own nature.

Even in the inorganic world the same thing is seen. Soil is washed away by a torrent, but both the extent and the mode of the denudation are determined by the nature of the soil itself as well as by the character of the torrent. Many solids melt

when exposed to heat ; but whilst wax liquefies at 65° C., lead remains solid till 335° C. is reached, and iron only leaves the solid state at a temperature of 1200° C.

Throughout then, it is seen that all change in any object whatever is determined both from within and from without. The extent and time of the change are mainly determined by action from without, but its character is, at any rate partially, determined by the inner nature of the thing.

Necessity
and Uni-
versality
of Law.

It is only when this is fully grasped that the conception arises that every change which takes place is necessary. And by 'necessary' is meant that given such a thing under such conditions, such a change must take place. This is the conception of the universality of law which marks modern scientific thought. We are apt to under-estimate the scope of this principle. As Professor Huxley put it : " Even thoughtful men usually receive with surprise the suggestion, that the form of the curl of every wave that breaks, wind-driven, on the sea-shore, and the direction of every particle of foam that flies before the gale, are the exact effects of definite causes ; and as such must be capable of being determined, deductively, from the laws of motion and the properties of air and water." ¹ Such an example shows how limited our knowledge really is. It is mainly under the pressure of some practical interest that men strive to extend their knowledge. And so it is only about a few classes of things and events that men consider it worth their while to think accurately—that is, to think truly, or to know. But accurate thought is scientific thought. We are apt to suppose that nothing belongs to science except those few phenomena about which men do try to think

¹ *Hume*, p. 122.

accurately. But the scope of science is the scope of the possibility of knowledge. As the late Professor Clifford said: "Scientific thought does not mean thought about scientific subjects with long names. There are no scientific subjects. The subject of science is the human universe; that is to say, everything, which is, or has been, or may be related to man." ¹

The scientific conception of the universality of law is, then, an attempt to explain everything which happens in the universe by the relations involved. If these are made clear, then, assuming that the nature of the 'things' related remains constant, any change is so far accounted for that it is shown to be consistent with what is already known of the action of thing on thing. But modern physics goes further and tries to explain the nature of the 'things' of ordinary life—the animal, the plant, the rock, the water—on the same principle. It seeks "the final constituents of the physical world in countless atoms, invisible from their minuteness, persistent in their duration, and unchangeable in their properties. These atoms . . . produce by the variety of their positions and motions the different kinds of natural products and their changeable development." ² The atom, then, is assumed to have no positive quality of its own to produce change—it simply persists unchanged as a centre of the action and reaction of forces. Change is thus the result of energy; it is only a rearrangement of the forces centred round the atom. Hence, the ultimate reality of the universe is found in energy, and this mechanical explanation of the world assumes its most developed form in the doctrine of the con-

Atoms and
Energy.

¹ *Essays*, p. 86.

² Lotze, *Microcosmus*, vol. i, pp. 31—32.

servation of energy. This theory is certainly simple, but, as an ultimate and complete explanation of reality, it is inadequate. It does not fully explain the whole of the phenomena of the inorganic world, whilst it is quite unable to deal with the phenomena of life, especially with those of development.

Explan-
ation of the
World as
System.

§ 8.—But even were this not the case, the mechanical theory does not give an ultimate resting-place for thought. For it looks upon everything which exists as dependent on its relations to something else. Now, if a phenomenon A is explained as due to the combination of B and C in a customary relation X, yet B, C, and X equally need explanation, and so with the factors which compose their causes, ~~Thus~~ we are driven into a series of explanations by relations which can never come to an end. Again, we must remember that when we speak of an event or a change, we are arbitrarily separating in thought one little piece of the world process which is not so separate in reality. As Mach puts it: "There is no cause nor effect in nature; nature has but an individual existence; nature simply *is*."¹ By nature here is meant the universe as a whole. That cannot be explained by its relations to anything else, for there is nothing else. This leads us to pass from the scientific to the philosophic stage of interpretation. The essence of this is that it regards the universe as a system whose changes are due to its own inherent activity. But the only self-originating activity we can conceive is that of thought and will; that is, of rational will. We are then compelled, if we push our search for explanation as far as it will go, to find in the universe the expression of the rational activity of an Absolute Being who includes all existence. Here, however, we have stepped beyond

¹ *Science of Mechanics*, p. 483.

the bounds of science into philosophy. As Dr. Merz says: "Science will not teach us to understand nature and life . . . it is the philosophical or religious problem."¹ But it is only when the intermediate or scientific stage has been passed through, and this ultimate stage reached, that education can be said to have accomplished its work. A conception of the necessary order of development such as we are sketching, is, therefore, a part of the essential equipment of the educator.

The idea of system is partially recognized in the scientific view. For according to it the universe is no longer looked upon as a sum of independent units, as in the interpretation of sense-perception, but as composed of parts in essential relation to each other. The philosophic view simply completes this idea of system and makes it the basis of all interpretation, and in doing so it takes up into itself what is true in each of the preceding modes of interpretation. It will be well, then, to consider briefly what is really meant by a 'system.' Let us do this by taking a piece of machinery, say a watch, as an illustration. The watch consists of various wheels, springs, and other 'works'; but these do not constitute a watch unless they are arranged in a certain definite way. The watch is, therefore, not merely the complete sum of its parts; there is no watch unless those parts are in certain relations to each other. Further, the meaning of each part depends on those relations; for its meaning is the share it plays in that work of measuring time for which the watch exists. But this share it is only able to perform through the action upon it of the other parts of the watch. A knowledge of its relations to those other parts will, then, enable us to

¹ *History of European Thought in the Nineteenth Century*, vol. i., p. 383.

understand *how* the part in question does its work. An insight into *why* that work is done involves however, a knowledge of the purpose for which the whole watch exists and of the relation of the activity of this part to the total activity by which that purpose is carried out. A complete comprehension, then, of any one part of such a system involves a knowledge of the relations of that part to every other part, and to the whole. Of course, these relations are of very different degrees of directness. But in a system there is no break, and therefore every part is connected, directly or indirectly, with every other part. Complete knowledge of any one part would include knowledge of all its relations—direct and indirect—and would, consequently, be knowledge of the whole. Of a small and artificial system like that of a watch such complete knowledge is attainable, but the wider and more complex a system is, the more difficult it becomes to reach such perfection of knowledge. Still the characteristic features of a system are the same, no matter what its extent and complexity. The scientific view then, by insisting on the essential part played by relations in the universe, begins to regard it as a system. The philosophical view by emphasizing the essential relation of each part to the whole, that is, the purpose or function of each part with respect to the whole, as that in which alone complete explanation can be found, develops and completes this conception.

Of this system of the universe the total knowledge of mankind is very imperfect. Still more imperfect is the knowledge of each individual man, for meagre as is the total knowledge of the race it is yet so extensive ~~as~~ compared with the limited capacities of each individual that no one can master more than a

small portion of it. Hence we have specialists ; that is, the totality of the field of knowledge is divided up into sections, and each thinker confines his efforts to a more or less limited section. These sections, which we are accustomed somewhat loosely to regard and speak of as separate ‘sciences,’ are more or less fully organized systems in themselves, and they are in turn divided by us into smaller constituent systems. The conception of system, therefore, determines all man’s attempts at organizing knowledge. We have a countless number of small systems, themselves constituents of larger systems, and so on till we reach the all-embracing system of the universe itself. And throughout all there is continuity of relation, so that even the smallest thing—a grain of dust or a passing whim—is in essential connexion with every other part and with the whole. As Tennyson beautifully says—

“ Flower in the crannied wall,
 I pluck you out of the crannies,
 I hold you here, root and all, in my hand,
 Little flower—but if I could understand
 What you are, root and all, and all in all,
 I should know what God and man is.”

§ 9.—But it may be asked “In what sense can this ultimate stage be called knowledge? Is it not rather a piece of philosophical imagination or of religious faith?” To answer this question we must investigate somewhat more fully the nature of knowledge.

Nature of
 Reality
 and of
 Knowledge.

Knowledge, as has been said, is an insight into the nature of reality. In other words, the object of knowledge is always some portion of that real world of which we ourselves form a part. Now we are brought into contact with reality in every piece of sense-experience. We look, and what we

see is independent of our wish ; we listen, and cannot determine what we shall hear ; we touch, but the surface touched is not influenced by our desires ; we taste and smell, but the resulting sensation is due to the object tasted or smelled. In a word, what we perceive is given us, is determined for us by the nature of the real world. Thus, reality constrains us, and it is this constraining power which marks off reality from fancy. But reality is not simply what we experience through our senses here and now. We find the same constraint in memory. We can recall our past doings and experiences, and much as we may wish them different from what they were, we cannot believe them different. They also are part of our reality. They form our real past, which is often as different as possible from the past we like to fancy. This same constraint is not felt as regards the future. That, indeed, we can often anticipate, but we know the anticipation is only more or less probable, it is never absolutely certain as is the past.

But neither present sense-experience nor memory of the past does more than put us in touch with reality. It gives us the material of knowledge, but not knowledge itself. Even in the simplest case, what is given to the senses has to be interpreted by thought. I see a yellow sphere of two or three inches diameter and I recognize it as an orange, and acting on this recognition I attribute to it many qualities and relations other than those now present to my senses. I say it is juicy and the fruit of a tree which grows in a warm climate. This and much more the little yellow sphere means to me. But very little of this is directly given in experience. Some of the rest has been given in my past experience, some I have received on the testimony of others,

some I have inferred. Or again, I wake in the morning and see the ground covered with snow, whilst my memory tells me there was no snow there when I went to bed the night before. I feel no hesitation in saying the snow has fallen from the clouds during the night. But I do not know this by sense-experience; I infer it. No doubt the inference is based on past experiences, but it is itself neither an experience of the senses nor the memory of such an experience. And, of course, even in explaining the white appearance which the ground presents to my sight as due to a covering of snow, I am going beyond sense-experience in the same way as in the case of the orange we have just considered.

Further, sense-experience leaves many gaps which thought must fill up. For example, I left my house this morning and returned to it this afternoon. I quite expected to find it standing just where and how I had left it. But it had not been presented to my senses all day, nor had I received the testimony of another to whom it had been thus presented. Yet I feel no doubt that it continued to exist, for otherwise I must assume that it comes into being just as some one happens to look at it or touch it, and goes out of being immediately it ceases to be perceived. But this is unthinkable, for it contradicts the only possible explanation of reality. If the existence of things were dependent on their perception, then obviously they could not compel that perception. But this contradiction is, of course, made manifest by thought, not by the testimony of the senses independently of thought.

Hence in every case we see that sense impressions have to be interpreted by thought before they can have meaning for us, and without meaning they cannot enter into knowledge. When so inter-

preted we call them 'facts.' A 'fact' then is a thing or event interpreted by thought. And this interpretation is, speaking broadly, the harmonizing the present experience with experiences received in the past.

Such interpretation may, no doubt, be wrong. The yellow sphere may be a skilful imitation of an orange, and not the fruit itself; the whiteness of the ground may be due to hoar frost, and not to snow. In such cases, however, further investigation shows the mistake by bringing to light something inconsistent with our suggested explanation. The mock orange contradicts past experiences of touch and taste; we find appearances in the hoar frost which we do not find in snow, or some one who has been out all night assures us that no snow has fallen. Truth cannot contradict itself; whenever, therefore, we find contradiction, we know that we have falsity. All thought must postulate this, for, without it, thought itself becomes impossible. Thus we do not hesitate to reject even personal testimony on the ground that it is inconsistent with the only explanation which will harmonize an enormous number of other experiences. For example, when "M. Louis de Rougemont" asserted that, whilst swimming in the sea ten miles from land, he could see the natives "putting out in their catamarans to help us,"¹ we declined to accept the statement as true, on the ground that the rotundity of the earth would make the alleged fact impossible unless those savages were some sixty-six feet in height. No one thought of accepting the writer's statement as a disproof of the general theory of the shape of the earth, for to do so would have been to accept as a fact a contradiction to innumerable other facts as to whose reality there can be no doubt.

¹ *Wide World Magazine*, October, 1898, p. 6.

Of course, it not infrequently happens, as has already been said, that what is at one time regarded as true is found at a later period to be false. This always takes place when some previously unknown facts are discovered which are inconsistent with the accepted explanation. We continually have examples of this in our daily life, and the phrase "Ah, that throws a new light on the matter!" indicates that the explanation which had hitherto been satisfactory to us, as harmonizing all the facts known, is now, by the knowledge of other facts inconsistent with it, found wanting. We must then seek a new explanation which will find a place for these new facts as well as for those formerly known. In the history of the world's thought probably the most striking example of this was the substitution of the theory that the sun is the centre of the planetary system for the theory that the earth holds that position. Here also it was the discovery of new facts which made the old theory untenable, though it had for centuries sufficed to harmonize all that was known of the motions of the heavenly bodies.

It appears, then, that consistency with all other knowledge is the test of truth, and it follows that, as knowledge is always advancing, it is often impossible to say with absolute assurance that any particular item of our interpretation of the world is true. Further knowledge may, in many cases, necessitate a revision of such interpretations in the future as in the past.

As knowledge grows, however, the amount of fully established truth is gradually increased. An item of interpretation must be held to be absolutely established as true whenever it is the only possible explanation of the facts. If the ground is covered with snow, snow must have fallen from the clouds.

The Test
of Truth.

Similarly, the assumption of the continuous existence of material objects independently of our perception of them is the only possible way of bringing consistency into our experience. Whenever, then, an explanation is 'necessary,' in the sense that to refuse to accept it would be to introduce contradiction into the thought and experience of mankind, that explanation is as much a part of knowledge as is the actual experience to which it gives meaning.

It is in these considerations that we find the answer to the question with which we began this section. It is in this sense of necessary explanation that we hold the theory that the universe is a self-determined system—the expression of a rational activity which manifests itself in all the changes which are, or ever have been, or ever will be—to be a matter of knowledge. It is the only interpretation which can harmonize the thought and experiences of mankind, and give a firm basis to knowledge. Moreover, the very fact that we can interpret the world and give a meaning to what goes on in it proves that the world itself is rational. Rational thought could find no meaning in a world which was not itself the expression of rational thought, for nothing but the rational has meaning. Without this assumption, man's knowledge is an edifice without foundation.

The World
as Mental
Construc-
tion.

§ 10.—We see, then, that in every case, great as well as small, the material of knowledge is given us—we cannot make reality other than it is. But, on the other hand, this material only becomes intelligible when it is interpreted by thought. It is thought which makes reality known to us. In this sense man may be said to construct his world. Indeed, each one of us constructs his own world, for each one of us comes into contact with reality in his own

individual experiences, and interprets those experiences according to his own amount of knowledge. But no two of us have either exactly the same experiences or the same knowledge. Consequently, each one of us sees the world from a standpoint somewhat different from that of all others, and sees it through a different medium of personal knowledge. Yet there is common knowledge, for all knowledge is of the same reality, and though there are many minds yet there is only one kind of intelligence. These different individual constructions of reality in thought are well likened by Dr. Bosanquet to "drawings in perspective of the same building from different points of view. . . . Our separate worlds may be compared to such drawings: the things in them are identified by their relations and functions, so that we can understand each other, *i.e.* make identical references, though my drawing be taken from the east, and yours from the west."¹ It is, then, only by comparison of the construction of reality of one individual with that of another, and the consequent correction and enlargement of each by each, that we have that common knowledge which represents the totality of individual knowledges and which is the extent to which mankind has grasped truth. This is the universal knowledge of which the individual knowledge of each one of us is but an imperfect reflexion.

It should be noted that this common knowledge is not the product of any one generation. It is the result of the attempts of countless generations of men to understand more and more of the world—attempts prompted from the first by practical needs, and in addition, in more civilized days, by the simple love of knowledge for its own sake. Every individual enters

¹ *Essentials of Logic*, p. 18.

into the heritage of the thought of the past, for he finds much interpretation current in the society into which he is born, and expressed in the language which he learns. Much of this knowledge he imbibes unconsciously, by imitation and by learning to use language, and much he receives by direct instruction from others. Thus, no individual takes up the task of trying to understand the world from the beginning; he accepts much that has already been done. Were it not for this no growth of knowledge would be possible. This it is which makes the common knowledge of mankind an ever swelling flood, and enables man to read more and more fully the riddle of the universe.

CHAPTER II

POSTULATES OF KNOWLEDGE

§ 1.—WE found in the last chapter that knowledge implies both a real world and intelligence capable of understanding that world. But though we can distinguish these two factors of knowledge, they cannot be actually separated. Neither can exist without the other. We cannot have thought about nothing; so thought cannot exist without the world. On the other hand, if any reality exists out of all relation to human consciousness, that reality does not exist for man. The world exists for each one of us just so far as he is aware of it, and no further. If we extend this thought, we are led to see that a reality which exists for no consciousness at all—human or divine—is absolutely unthinkable, because it is devoid of meaning. We must not, therefore, think of man and of the rest of the universe as two separate orders of existence in no essential relation to each other. The universe is the whole of existence including man, and it is only because man is an integral part of the universe that he can enter into that relation to it which we call knowledge.

The
Factors of
Knowledge.

Postulates
of
Knowledge.

§ 2.—This relation starts with the very beginning of experience. As Dr. Bosanquet puts it, "Experience may be said to begin with the certainty that 'there is somewhat.'" ¹ The growth of knowledge is just the fuller and fuller understanding of that "somewhat." Now, this growth has been the work of many minds continued throughout long ages. Such co-operation in the increase of knowledge is only possible on the assumption that human intelligence always works fundamentally in the same way. Its products indeed differ, for they include all attempts to explain the universe, from that of the rudest savage to that of the most profound philosopher. But this difference is due to the different starting points made possible by the growth of knowledge itself, not to differences in the principles on which interpretation of experience proceeds. Such common principles can be found by analysing the process of acquiring knowledge. They are called the *Postulates of Knowledge*, because they are presupposed in all knowledge from the very beginning, and are the very life-blood of its growth. As knowledge grows these postulates get a wider and deeper meaning, but in their essential nature they are the same throughout.

Of these Postulates of Knowledge four are of great importance. They have long been named the Principles of (1) Identity, (2) Contradiction, (3) Excluded Middle, (4) Sufficient Reason. As they are all operative together and each is more or less closely involved in each of the others, instead of examining them separately it will be convenient to discuss their combined scope at each of the three great stages of interpretation of the world brought out in the last chapter—that of sense-perception; that of law; that of system.

¹ *Logic*, vol. ii, p. 206.

The
Postulates
at the
Stage of
Sense-per-
ception—

§ 3.—The distinguishing mark of the stage of sense-perception—which may perhaps be called that of uneducated common sense—is that the common ‘things’ which man perceives by his senses are the ultimate forms of reality. Relations are regarded as indifferent; the things stand fast like “the everlasting hills,” whilst relations form and scatter around them like the clouds, and with no more effect on their real nature. To this view, the world is a sum of separate and independent units, and the highest aim of knowledge is to classify and describe these correctly.

Identity.

Here the *Principle of Identity* is most prominent. It asserts that the real nature of everything is constant. This does not deny difference or change. Indeed it is only amidst diversity that identity is ever known. Oak-trees differ in size, shape, position, and in many other ways, yet they have an identical nature, shown in a general identity of life-history. Time brings changes to all things more or less rapidly, and we learn what amount of change to expect, and refuse to recognize identity at all if that change is not there. If I see a child to-day whose appearance seems to me to coincide with that of a child I knew thirty years ago, that very resemblance will prevent me from believing that he is the same person. Identity, then, is always found amidst diversity.

Contradiction.

The *Principle of Contradiction* is essential to give a full and precise meaning to that of Identity. It asserts that the same nature cannot have contradictory qualities, or, in other words, that a statement and its denial cannot both be true. Of course, the statement and its denial must both refer to the same piece of reality at the same time. Yesterday I could truly say, “I have a headache”; to-day with equal truth I can deny the headache. But these two

statements are not contradictory, or in any way incompatible, for though both refer to "I," yet the "I" in the one case is the "I of yesterday" and in the other case the "I of to-day." Indeed the principle of Identity may be expressed by saying that "what is once true is always true"—for if the statement refers to anything which changes with time, it does so within definite time limitations. The time limits may be very narrow, as in the case just quoted, or they may be of considerable extent. When a statement concerns the essential nature of a thing, its time limits are coextensive with the existence of that thing. Thus the statement that "oaks spring from acorns" must be held as true for all oaks that ever have been or ever will be in the world. Here we see how the principles of Identity and Contradiction complement each other: that of Identity says: oaks *are* always produced from acorns; that of Contradiction denies that they *can* ever be produced in any other way, or that any other growth can spring from acorns.

*Excluded
Middle.*

The *Principle of Excluded Middle* affirms that either a statement or its denial must be true, and thus completes the Principle of Contradiction, which says that one of them must be false. An important bearing of this is that when we prove a statement to be false we necessarily prove that its denial is true. Of course, this principle must be understood with the same strictness as those we have already discussed. It does not imply that we are always sure which of two contradictory statements is really true. In every case of doubt we are unable to decide this because, in some way, we have not sufficient knowledge of the matter in hand. We may be unable by lifting them to determine which of two nearly equal weights is the heavier, yet one of them is

the heavier, and a pair of scales may decide the question. The doubt is not in the things themselves, but in our interpretation of the effect they produce upon us.

The *Principle of Sufficient Reason* affirms that everything is capable of explanation. At the stage of knowledge we are now considering such explanation is always imperfect, and very often more or less fanciful. As we saw in the last chapter, savages—who are the most thoroughgoing representatives of this stage of thought—do seek explanation, but they seek it mainly in the activity of supposed supernatural beings. Indeed, as soon as men seriously seek an explanation for the events they see around them, they begin to pass into the next stage of thought.

Sufficient Reason.

§ 4.—The characteristic of the second—or scientific—stage of interpretation is the attempt to explain everything in the world by its relations to other things. As has been already pointed out, modern physical science pushes this explanation of the things of sense-perception so far that it nearly explains them away altogether. It finds the ultimate reality in the relations to each other of simple and unchangeable atoms, and teaches that constancy in the nature of ‘things’ is due to constancy in the relations between their constituent atoms. The principles of *Identity*, *Contradiction*, and *Excluded Middle* are, therefore, given a wider application. They apply now primarily to the relations of atoms, and only secondarily to the ‘things’ constituted by such relations.

The Postulates at the Stage of Law.

Moreover, modern science insists on the truth that these ‘things’ are in relations to each other, and change with every alteration in such relations. The actual phenomena of the universe can, then, only be

understood when relations of thing to thing are investigated. This emphasizes the *Principle of Sufficient Reason*, but also involves the other principles. For as similarity in the nature of things is explained by the assumption of similarity in relations between the constituent atoms, so similarity of change is explained by assuming similarity in the relations of the things involved. We speak here of 'similarity' rather than of identity, because, as has been already pointed out, identity is never found except amidst diversity, and 'similarity' expresses this very combination, and is, therefore, the most appropriate term to apply to the actual events which take place in the universe. In all similar phenomena there is an element of identity to which the similarity is due, and on the basis of which alone we can infer from one to the other. But this element of identity is by no means always on the surface; in many cases, indeed, we have to assume its existence without being able to specify exactly either its nature or its extent. As Mill reminds us: "The course of nature, in truth, is not only uniform, it is also infinitely various. Some phenomena are always seen to recur in the very same combinations in which we met with them at first; others seem altogether capricious; while some, which we had been accustomed to regard as bound down exclusively to a particular set of combinations, we unexpectedly find detached from some of the elements with which we had hitherto found them conjoined, and united to others of quite a contrary description."¹

To first experience, then, the world is chaotic, and, as we have seen, the savage so regards it. This is because he applies the Principle of Identity only to things, in the independent nature of which he seeks

¹ *Logic*, vol. i, p. 359.

all explanation. "Man after man dies in the same way, but it never occurs to the savage that there is one constant and explicable cause to account for all cases. Instead of that, he regards each successive death as an event wholly by itself—apparently unexpected—and only to be explained by some supernatural agency."¹ It is only when the importance of relations is recognized and the postulates of knowledge applied to them, that the conception that underneath all the apparent confusion of phenomena there is an always present and essential uniformity begins to govern man's mode of interpreting his experiences. Then science begins, for man recognizes that upon him "is imposed the task of everywhere seeking out in the natural phenomena those elements that are the same, and that amid all multiplicity are ever present."² When such elements are found, the work of science is done. "When once we have reached the point where we are everywhere able to detect the *same* few simple elements combining in the ordinary manner, then they appear to us as things that are familiar; we are no longer surprised, there is nothing new or strange to us in the phenomena, we feel at home with them, they no longer perplex us, they are *explained*."³

The explanation given by science, then, consists in *Causation*. determining the conditions under which any change or event takes place. And the whole of these conditions together are styled the *Efficient Cause*—or simply the cause—of the phenomenon in question. The *Principle of Causation* is, then, one aspect of that of Sufficient Reason. Its most general axiom is: (1) "Every event must have a cause." Then, in combination with the principle of Identity and its

¹ Lionel Decle, *Three Years in Savage Africa*, p. 512

² Mach, *Science of Mechanics*, p. 5. ³ *Ibid.*, pp. 5--6,

complementary principles, it assumes uniformity in causation in the axioms—(2) “The same cause always produces the same effect;” (3) “The same effect is always due to the same cause;” (4) “Cause and effect are equal in amount of energy.”

‘Every
Event has
a Cause.’

‘Same
Cause, same
Effect.’

As we have seen, the first of these four axioms is implied in all attempts to explain the world; even the rudest savage assumes it. But the other three axioms are only operative when explanation is sought in relations. Then, as man’s early seekings after knowledge are always motivated by practical needs, the uniformity of causation appeals to him first in the light of the second axiom. He is interested more in what will result from certain conditions than in the inverse problem of what conditions will produce a given result. Hence, he studies causation mainly from the point of view of the cause. In other words, he analyses more or less carefully the conditions that will give a certain desired result, and he assumes that if the result comes in one case it will come in all, provided that he secures the same conditions. He applies the principle of Causation forwards.

‘Same
Effect, same
Cause.’

But the result obtained is often a very general one, and man’s practical needs do not usually prompt him to analyse it carefully. Hence it often appears to superficial observation that the third axiom is not true, and that the same effect may be produced by different causes on different occasions. If this were so, the principle of Causation would be one-sided, for the principle of Identity would be only half applicable to it. And, indeed, this was the common opinion till quite recently. Even the savage recognizes some uniformity of causation in cases in which his own activity in carrying out his own purposes plays an important part. He desires to kill his enemies or the animals he requires for food, and he

knows he can do this in a variety of ways. When he sees death which has not resulted from visible violence, he assumes that a similar destructive activity is exercised by malignant spirits. Death, then, to his mind, obviously results from a variety of causes. Nor is the savage alone in this rough and ready way of interpreting events. Even so great a logician as Mill says : " It is not true that only one effect must be connected with only one cause, or assemblage of conditions . . . many causes may produce death." ¹ But in speaking of " death " Mill shows that he has not applied the same searching analysis to the effect which he tells us is necessary to discover the cause. Every coroner's inquest is an attempt to perform such an analysis, and of necessity proceeds on the assumption that exactly the same kind of effect can have only one cause. There is no such thing as death in general ; every death is one particular kind of death, and in speaking of ' death ' as the effect of a bullet through the head or of swallowing arsenic, we are either using the word very loosely or we are picking out from the total effect the one factor which is of the greatest personal interest. A hole in the head is just as much part of the effect of the bullet in the first case as is the death, and similarly a particular condition of the organs of the body results from taking arsenic just as surely as does death.

No doubt, at first sight it seems certain that the same effect is due now to one cause, now to another. " Thus friction, combustion, the liquefaction of a vapour, freezing, pressure, all produce heat. What could be more apparently disparate than these agencies ? Yet all of them alike involve the liberation of molecular motion in accordance with mechanical

¹ *Logic*, vol. i, p. 505.

laws common to all the cases.”¹ This example admirably brings out the difference between the popular and the scientific views of causation. The former confines itself to the sphere of sense-perception, and finds causation in the influence of one visible and tangible body upon another; the latter seeks it in an analysis of the process which brings to light a persistent and identical nature changing in determinate ways under definite conditions. In all cases, such an analysis is a task of difficulty; in many, it has not yet been accomplished. But the belief that, when such an analysis is found possible, it will always reveal an underlying identity, even amidst the greatest apparent diversity, is involved in the acceptance of the axiom that causation is uniform.

‘Cause and
Effect
equal in
Energy.’

As the third axiom was recognized later than the second, so the fourth can only be recognized when the third is accepted. It is a yet further application of the principle of Identity to that of Causation, and when stated in its most general form it becomes the doctrine of the conservation of energy—that the amount of energy in the world is not subject to either decrease or increase, but only to change in mode of expression. This is one of the latest conceptions of modern physical science, but we see in it only the further application of the same principles of interpretation which have been operative from the first in the development of knowledge.

Causation
and
Sequence
in Time.

A consideration of these axioms of causation makes it evident that, in another respect, the common way of regarding causation is indefinite. We constantly look upon the cause as necessarily preceding the effect in time. Indeed, not infrequently mere succession in time is mistaken for a true causal connexion, as when the appearance of comets is held to

¹ Hobhouse, *The Theory of Knowledge*, p. 366.

be the cause of a war or other calamity, which may follow shortly after. It can be easily shown, however, that the cause does not always precede the effect. A blot is the effect of letting a drop of ink fall on paper, but the blot does not follow the contact of ink with paper; its appearance is simultaneous with that contact. So the height of the mercury in a barometer is the effect of the pressure of the atmosphere, but it is simultaneous with that pressure. In other cases, the effect seems subsequent to the cause. A cricket ball is struck by a bat, and the motion of the ball is subsequent to the stroke which was its cause. But here again we want a deeper analysis of the process. The impulse given by the bat is communicated to the ball in the moment of impact, and not subsequently to that moment. Thus it is the accumulated effect which is subsequent to the original stroke, and further analysis shows that we have a continuous transition of events each of which is at once cause and effect.

Whether we say, then, that effect follows cause or is simultaneous with it depends upon how we are using the terms. This is admirably put by Whewell: "The instantaneous effect or change is simultaneous with the instantaneous force or cause by which it is produced. But if we consider a series of such instantaneous forces as a single aggregate cause, and the final condition as a permanent effect of this cause, the effect is subsequent to the cause. In this case, the cause is immediately succeeded by the effect. The cause acts in time: the effect goes on in time. The times occupied by the cause and by the effect succeed each other, the one ending at the point of time at which the other begins."¹

In brief, we must remember the continuity of

¹ *History of Scientific Ideas*, vol. 1, pp. 197—198.

change in the world, and the artificial character of what we single out as 'events.' As Mr. Hobhouse says: "No event ever begins or ends; but a process goes on which passes gradually from one phase into another. We ticket prominent or clearly distinct phases with separate names, and speak of them as different events; but we must remember that, though in one sense they are different, there is yet no barrier."¹ 'Cause' and 'Effect,' in the common use of the terms, are but separate names for artificially limited earlier and later phases in one continuous process.

Causality is, then, a principle on which the human mind acts from the first. It is not gathered from sense-experience, for it is involved in all interpretation of such experience. "*What* causes produce what effects; what is the cause of any particular event; what will be the effect of any peculiar process; these are points on which experience may enlighten us. . . . But that every event has *some* cause, experience cannot prove any more than she can disprove."² Nor can experience demonstrate that one cause is universally connected with one effect. But this is assumed in the statement of every scientific 'law,' for such laws assert that a causal relation which has been observed in a limited number of cases holds true throughout the universe, and this is, obviously, not a matter which can be either proved or disproved by observation. The establishment of such laws is the ideal of knowledge at this stage.

§ 5.—We saw, however, in the last chapter, that explanation by bringing a particular case under a general law cannot be ultimate, and that we are driven by the necessities of thought to regard the

The
Postulates
at the Stage
of System.

¹ *The Theory of Knowledge*, p. 277.

² Whewell, *op. cit.*, p. 174.

universe as one self-determined system. With this conception we have obviously a very considerable extension of the principles of interpretation beyond their application in the scientific stage. The universe itself, as well as its constituent parts, is now regarded as embodying those principles. It is thought under *Identity* as a continuous unity retaining its essential nature amidst all the infinite number of varied manifestations of that nature. Under *Contradiction* it is thought as essentially consistent ; as containing no contradictions. This is why we find contradiction always a proof of error, for this principle compels us to recognize that error cannot ultimately be made consistent. Under *Excluded Middle* we think of it as a system of mutually-determined parts. Lastly, under *Sufficient Reason* we regard it as furnishing in the relations of part to part the first stage of explanation, and in the relation of parts to the whole an ultimate explanation.

In discussing the scientific method of interpretation we saw that it is mechanical, that is, it explains one phenomenon by its relations to others according to mechanical laws. We have also seen that this explanation is not final. The conception of efficient cause which dominates scientific interpretation is supplemented in the philosophical stage by the conception of purpose. This is inherent in the conception of system. To revert to the illustration of the watch. The efficient cause of its marking the time is the relation of part to part. But that does not explain *why* the watch exists. This is found in the human purpose which it serves. The watch is planned and made by man just for that very object, and without it the watch would not exist. This conception of purpose—or *Final Cause*, as it is frequently called—is moulding more and more man's

Final
Causes.

interpretation of the world. Of course, the purpose is not always relative to man. It is so in the case of things like the watch, which he invents and makes to serve his own ends. But we have got beyond the stage of thought in which sun, moon, and stars were regarded as existing solely for the purpose of giving man light, and in which efforts were made to find a reason for the existence of everything by showing that it is of some use to man. Such an attempt was common enough even in the last century, and perhaps reached its highest point of absurdity when the existence of noisome domestic insects was accounted for on the ground that such pests induced personal cleanliness.

We now regard each form of existence as having its own purpose. Of course such purpose can only be known by beings endowed with minds. Man can aim at attaining a certain form of character, and even the lower animals are conscious of wants which they strive to satisfy. But the modern doctrine of evolution finds progression in the vegetable as well as in the animal world, and we may quite intelligibly speak of the purpose of the existence of oak-trees as the gradual attainment of the perfection of oak-tree life. Even in the inorganic world we must think of all change as the gradual attainment of some end, though we must not try to find that end in reference to the needs of men. In so far as any thing freely manifests its own nature it may be said to fulfil its purpose. Thus we think *all* change as having an object, though that object is often hidden from us. As Dr. Harris puts it: "In the view of evolution there is a goal towards which relatively lower orders are progressing, and the facts, forces, and laws are seen as parts of a great world-process which explains all. At this point science rises into

philosophy. . . . When science comes to study all objects in view of the principle of evolution, it has transcended the stage of mind whose highest object is to discover classes ; likewise the stage that makes law an ultimate. Besides efficient cause, which makes or produces some new state or condition, there is 'final cause' or purpose—design or 'end and aim.' ”¹

¹ *Psychologic Foundations of Education*, pp. 19—20.

CHAPTER III

KNOWLEDGE AND LANGUAGE

Ideas and
Knowledge.

§ 1.—WE have seen that all knowledge consists in correctly interpreting or giving a meaning to experience, and that such interpretation means the harmonizing this experience with others. Or we may put it in another way, and say that to give meaning to any piece of reality is to think it in its proper place in an appropriate system. But systems of reality exist in consciousness as mental constructions, or *ideas*. Hence, to give meaning is to think an experience under an idea already existing in consciousness. We may say, then, that experience as interpreted is made up of ideas, and that knowledge consists of all those ideas which are proved true.

Ideas and
Reality.

§ 2.—But reality to each of us is only our experience as thus interpreted. Therefore, by 'ideas' is meant the way in which the mind grasps reality. Every known piece of reality *exists* in consciousness as an idea. It is not merely *represented* in consciousness, as if the world of reality were separate and distinct from the world of knowledge. We must not, therefore, think that things in the eternal world impress copies of themselves upon our

minds, as a seal stamps impressions on wax, or as the image of an object is impressed on a photographic plate. It is true the retina of the eye does act very similarly to a photographic plate, but the eye is not the mind, and the retinal image is not itself in consciousness.

§ 3.—It is true also that we talk of the “eye of the mind,” and that most people can call up more or less vivid and distinct mental images of absent objects. Images, however, are not ideas, but only symbols of ideas. Just as the shape and colour of an orange are symbols of all else that ‘orange’ means to us when the orange is actually present to perception, so the visual image of an orange acts as a sign in exactly the same way. The idea is the meaning which the mind finds for the present experience by referring it to other experiences, and any mental image that may come into the mind is only an example or illustration of that meaning.

Ideas and
Images.

In many cases, indeed, such images do not correspond to the idea, and when present tend to obscure meaning and hinder understanding. “We can image some object that is acted upon by force—we can image it before it is acted upon and after it is acted upon. That is to say, we can image the results of the force, but not the force itself. We can think of force, but not image it.”¹ To “have an idea” of anything is, then, to know its nature and meaning; in other words, to *think* it, not to *look* at it either in reality or as represented in a mental image.

Doubtless, real thought is difficult, and many persons are satisfied to substitute for it panoramas of mental pictures. This tendency is promoted by “what we may call the Photographic writing which alone obtains at present. For a long while back, writers

Thought
and
Imagina-
tion.

¹ Harris, *Psychologic Foundations of Education*, p. 40.

have desired to write only to our eyes, not to our thoughts. History now is as a picture-gallery, or as a puppet-show ; men with particular legs and particular noses, street-processions, battle-scenes,—these—images—all images !—mow and mop and grin on us from every canvas now. We are never asked to think—only to look—as into a peep-show, where, on the right, we see *that*, and on the left *this* !”¹

It is true, as Dr. Stirling himself reminds us, that images “are always the beginning, and constitute the express conditions, of thought.”² Whilst an individual is in the first stage of thought—that of sense-perception—he will not have separated his meanings from his images and his percepts. But unless we pass beyond this stage to that of the abstract idea, or meaning, “we never attain to mastery over ourselves, but float about a helpless prey to our own pictures.”³ This is so because all such pictures are of individual and particular things, and every particular exhibits qualities and relations of its own, which are not part of the meaning, and which obscure that meaning. For example, all who have worked problems in geometry know how easy it is to be misled by some accidental feature of the particular diagram we draw, or picture in our minds, to aid us in the solution. We desire, it may be, to establish some relation of triangles in general, and the particular triangle we draw has perhaps two of its angles equal, and we are apt to treat this accidental relation as essential, and base our proof upon it. In contrast to the particular image, meaning is always universal ; that is, it is common to all pieces of experience which we think under the same idea.

¹ Stirling, *The Secret of Hegel*, p. xlii.

² *Ibid.*, p. xliii. ³ *Ibid.*

§ 4.—If we now ask how knowledge, or a system of meanings, develops in an individual mind we are at once met by a theory once very commonly accepted but now proved to be thoroughly false. According to this theory, the mind begins with ideas of individual things, then, by comparison, classes them together, and so goes on to construct its world in a manner very similar to that in which a brick-layer builds a wall. Nothing could be farther from the truth. Modern psychology has thoroughly established that the mind begins with a vague apprehension of its experience as a whole, and then little by little divides this up, as this or that piece of experience secures its interest and special attention. As Dr. Bosanquet suggests, the process may be illustrated by “the discernment of features in a distant landscape which prolonged attention even without optical assistance has the power to effect.”¹ The process starts from the whole, not from the elements. Ideas of classes are formed out of wider and vaguer ideas as striking differences attract the attention. The first idea is of a vague “something,” and from this by continual division more and more definite ideas of different forms of reality are evolved. But at every stage the ideas reached are used to interpret fresh experiences which are gathered under them. Thus in the process of the development of knowledge, analysis—or splitting up, and synthesis—or binding together, go hand in hand.

Develop-
ment of
Ideas.

§ 5.—This process would be impossible without a system of signs by which, on the one hand, attention can be concentrated on one element in the complex whole of which experience at every moment consists, and on the other hand, the ideas, when once reached, can be represented symbolically in consciousness.

Ideas and
Language.

¹ *Logic*, vol. i, p. 32.

Any such system of signs is a language. Thus, even in the individual mind, knowledge could not develop without a language of some kind.

Language
and Commu-
nication of
Knowledge.

§ 6.—Even easier is it to see the necessity of language when we consider the growth of knowledge, not in an individual mind, but in the race. We have seen that this growth depends on communication of knowledge between men. But such communication implies a common language, or system of signs whose reference to reality is generally accepted and understood. This, in turn, implies that the signs are also instruments of individual thought : language as a means of communication rests upon language as a means of individual thought.

Verbal
Language.

§ 7.—Of all systems of signs for thinking and communicating thought, words are by far the most convenient, because, owing to their conventional and artificial character, they can sustain a much more general and abstract meaning than can any other thought-symbols. Thus, as knowledge advances, language becomes more and more exclusively verbal. Savages convey much of their meaning by descriptive gestures, and some of the least developed in intelligence have so poor a language of words that they cannot understand each other in the dark, because the gestures which fill out their speech cannot be seen. But gestures have very similar disadvantages to mental pictures as symbols for thought. Like visual images they can only represent the outward and visible qualities, and these are frequently far from being the most important. Gestures are also frequently doubtful in their reference ; a flapping of the arms, for instance, may represent either a bird, or the act of flying. With a language wholly or mainly of gestures, then, knowledge could advance but a little way even on the stage of sense-perception. Hence,

a system of conventional signs, capable of expressing meaning with any required degree of definiteness, is essential to really developed thought. Speech fulfils this requirement, and has the additional advantages that it is easily produced, can be used as a means of communication in the dark as well as in the light, and between persons at some distance from each other, an advantage which the modern applications of electricity have enormously increased.

Writing is, of course, only verbal language in another form, but it plays a part in the development of knowledge which nothing else could have played, in that it extends the communication of knowledge to an indefinite extent, and renders possible contact of any one individual mind with many other minds both in the present and in the past. It is mainly by means of written language that the knowledge of the individual on the one hand contributes to the knowledge of the race, and on the other hand is checked and corrected by it. And such correction is necessary. For, as experience is interpreted by experience, and as the experiences of every individual differ from those of every other individual, it follows that various interpretations of the same piece of reality may be given by different persons. Were the interpretations of each person wholly dependent on his own narrow range of experience, this would certainly be the case to an appalling extent, and, of course only one at most of a set of incompatible interpretations can be true. Even now we find plenty of such variations; every "difference of opinion" is a case in point. But when we can test our ideas by the experiences of innumerable other people, we are much more likely to reach the truth at last. Such testing goes on throughout life by means of both written and spoken language.

Writing.

Language
and
Learning.

§ 8.—When a child learns his mother tongue, the words he acquires are from the first signs of ideas, in that they are referred to certain pieces of reality. His ideas are doubtless extremely imperfect at first, but the fact that the reference to reality is the same to him and to others, renders instruction possible. He may, for example, find himself ignorant of nearly everything concerning a certain flower which he has seen and the name of which he has learnt. But he can seek instruction from another person whose idea of that flower is full and accurate, and therefore very different from his own. And he can do this because, though the ideas are different, yet their reference to reality is the same. And that identity of reference is marked by the name, so that to utter the name indicates *what* the child wants fuller information about as clearly as showing the actual flower would do. But such instruction is effectual only so far as the teacher uses words which have a clear meaning to the child, that is, which call up in his mind definite ideas. It is by combining these ideas that he is led to form a fuller and more accurate idea of the flower than he had at first.

The same process makes it possible to lead the child to form ideas of parts of reality he has never experienced. “We wish to describe quicksilver to a child. We say that it is something like this pewter in its brightness and the way it reflects the light; it is even heavier than this lead; it is liquid like water, so that I could pour it from one vessel to another. And we might further qualify each of these statements so as to render them more exact. Now, we may assume that all the words in which the quicksilver is described are significant to the child; if they are not significant the description so far fails. At the end, if he have good powers of

synthesis, he may combine these particular properties thus signified into the new idea we wish him to form. The word 'quicksilver' then becomes significant to him."¹

It is in this way that we all gain knowledge indirectly, through the verbal testimony of others to parts of reality which we have not ourselves experienced. It is evident, however, that such indirect knowledge must rest ultimately upon that direct knowledge of reality which springs from our own experiences, and which alone can give meaning to the language by which indirect knowledge is communicated. It is this which makes it all important that in early life, not only should the ideas which a child gains through careful examination and analysis of direct experience be as numerous, full, and exact as possible, but that they should be correctly associated with language. This is the foundation of that thorough command over language without which all good mental work is impossible, and which it is, therefore, one of the chief duties of the educator to develop in his pupils.

§ 9.—Communication of thought and knowledge, then, depends on the existence of corresponding ideas in different minds. By "corresponding ideas" is meant ideas which refer to the same reality and give substantially the same meaning to it. The ideas of different people will hardly coincide more closely than this, owing to the differences of experience from which those ideas have sprung.² Now it is evident that if the ideas of the hearer or reader differ materially from those of the speaker or writer, grave misunderstanding may arise. This may be avoided in oral communication by questioning, on the one side

Spoken and
Written
Language

¹ Lloyd Morgan, *Psychology for Teachers*, p. 178.

² Cf. p. 25.

or the other, on any point whose interpretation seems doubtful. But writer and reader are much more at each other's mercy. On the one hand, the reader may bring a number of false preconceived ideas to the interpretation of his author, or he may read carelessly and hurriedly. In both cases wrong meanings are attributed to the writer and the corrective of oral intercourse is absent. As Plato long ago said, "Speeches . . . when they have been once written down are tumbled about anywhere among those who may or may not understand them, and know not to whom they should reply, to whom not: and, if they are maltreated or abused, they have no parent to protect them; and they cannot protect or defend themselves."¹ On the other hand, the writer may have expressed himself obscurely, and the reader be unable to grasp his meaning, not from carelessness or poverty of ideas, but from being doubtful exactly what it is the author wishes to say. A question would lead to the solution of his difficulty, but if you question a printed page it "always gives one unvarying answer."² On the other side, it may be truly urged that the printed page has an advantage over the oral teacher in that it is always ready to be questioned, and bears the dulness or perversity of the scholar with a great deal more patience than the living teacher is apt to do.

Meaning
and
Context.

§ 10.—The liability to misunderstanding is enormously increased when speech is ambiguous. Ambiguity is possible because every word has its meaning partly determined by its context. As was pointed out in speaking of the development of ideas, we do not begin with ideas of separate things and weld them together, but we begin with a vague idea of a whole which we have to analyse. Now,

¹ *Phaedrus* (Jowett's Translation), p. 275.

² *Ibid.*

language symbolizes ideas. We must look for the beginnings of language, then, in actual speech, not in isolated words. Indeed, in early stages of language there is no division into words, either in speech or in writing. "It is always very late in the day before the seminal principles of speech are detected and explained. Indeed, the language which owed to them both birth and growth may have ceased to be a living tongue before these, the regulative elements of its formation, come to light and are embodied in written grammar. That most elementary species of instruction which we familiarly term the A, B, C, had no express or articulate existence in the minds or on the lips of men, until thousands of years after the invention and employment of language; yet these, the vital constituents of all speech, were *there* from the beginning."¹ Knowledge of language, like knowledge of every other part of reality, works at first from the whole towards the elements.

All portions of speech, then, depend for their full meaning upon the context in which they exist. For example, my idea of the relation of logic to education is expressed in this book as a whole, though even that total idea, as we may call it, owes its character to its relation to the rest of my mental life. However, taking that as a sufficiently self-contained whole, it is evident that the full meaning of each chapter involves the relation of the idea expressed by that chapter to the whole idea developed in the book. Similarly, the idea set forth in each paragraph depends for its full meaning upon its relation to the rest of the chapter; the idea expressed by each sentence is relative to the paragraph of which it forms a part. With the sentence we have reached

¹ Ferrier, *Institutes of Metaphysic*, p. 15.

the unit of thought. It is true that the sentence is composed of words, and if we speak or write it, the words have to appear separately. But in thought the sentence exists as one idea. We may write or say "The ground is covered with snow," but that expresses a single and undivided fact of experience. We are so accustomed to the grammatical treatment of language as composed of words, and to seeing single words defined in a dictionary, that we are apt to overlook the truth that isolated words are, as Mr. Hobhouse well says, mere "dead fragments of language."¹ If we hear an isolated word, *e.g.*, "Fire," we either regard it as an abbreviated sentence—that is, as intended to convey some information—or we are thrown into a state of mental perplexity as to what idea the speaker wishes to convey. It is related that a famous head-master once dumbfounded the whole of his sixth form by commencing a lesson with a question propounded in the single word 'Abraham?' Such considerations make it clear that each word depends for much of its meaning on its context. For example, we speak of a *bright* day, or a *bright* boy, but the force of "bright" is by no means identical in the two cases. The word, then, is relative in meaning to the sentence, and the sentence to the context in which it occurs. Isolated sentences, like isolated words, do not occur in actual thought, though they have to be used for illustrative purposes in text-books on logic and grammar. But if we take such a sentence as "The fire is out" we see at once that its meaning is very different when it is spoken in reference to my study or to a row of warehouses. The same is true throughout: a sentence—despite the assertions of many grammar books—does not express a *complete* thought, but only

¹ *The Theory of Knowledge*, p. 164.

the smallest separable element in the ever-moving and living thought process.

The exact meaning, then, in which sentences or words are used is determined by the general topic of thought. That is why no confusion is caused by the fact that some verbal signs have two or more distinct meanings, as, for instance, a 'page' may be a boy or a piece of paper. No doubt ever arises in the use of such signs, though their existence makes punning possible. In fact, as they stand for distinct ideas, they are really distinct words, though they happen to have the same form. When we hear a lecture or read a book each portion receives much of its meaning from all that has gone before. Indeed, it is often impossible to understand the latter part unless the earlier has been grasped. Frequently, too, the meaning is shaded by our anticipation of what is coming. We see, then, that we can only fully appreciate the meaning of words when we think of them as elements in sentences which are themselves elements in an organic whole or system of thought.

Every word, then, as used in the expression of actual thought, has a specific meaning which varies according to the context in which it occurs, that is, according to the system of thought it helps to express. Still, these specific meanings have much in common. There is to every word a general meaning which is always present and forms the bond of connexion between the many occasional meanings, and this general meaning when explicitly stated we call the definition of the word.

The nature of definition will be considered in a later chapter; ¹ it is sufficient to point out here that even when we have clearly grasped the true general meaning of a word, we never use the word in that general sense alone. Just as there is no such thing

Specific and
General
Meanings of
Words.

¹ See Chapter xvi.

as a child in general corresponding to the general idea of child, but every embodiment of that general idea is a very individual little boy or girl, so every time we use the word 'child' in a real process of thought the general idea which corresponds to that word is modified by the nature of the particular thought. Our knowledge of general meaning, then, does not alter the fact that in actual use every word is modified in meaning by its context; the general meaning is a kind of nucleus round which the occasional meanings wax and wane, but some such occasional meaning is always present.

Even in scientific terms, where the general meaning is not only most definite but most prominent, there is yet a slight occasional meaning. 'Oxygen' has a quite fixed meaning, but when we think of oxygen we always do so in some particular connexion—for example, as combining with hydrogen to form water—and so the whole thought determines the exact force of the word 'oxygen' in the actual sentence. Scientific terms, however, are much less flexible than the words of ordinary speech. Fortunately they are generally so long and so ugly that there is little danger of their ever becoming constituents of ordinary discourse. We say fortunately, because it would be a great loss were language to decrease in flexibility. The tendency, however, is naturally all the other way. And it should be noted that this flexibility marks the meanings of all words. Even such a little word as *in* differs in meaning in such sentences as "I am *in* trouble" and "I am *in* London;" and the equally simple word *and* can be used conjunctively or adversatively. Indeed, every word whatever is always a factor in expressing a certain idea and has its meaning modified according to the idea to be expressed.

§ 11.—There are enormous advantages in this flexibility of meaning, for it makes it possible to express an innumerable number of shades of meaning with a comparatively limited vocabulary. The English peasant expresses all his thoughts with a few hundred words, and it is computed that even Shakespeare made use of only some twenty thousand words; yet what a wealth of thought and feeling he uttered with them! But, like all other good things, the flexibility of meaning has also a grave disadvantage—the consequent liability of language to become ambiguous to which reference has already been made. Now ambiguity is at bottom indefiniteness in the reference to reality. Such indefiniteness may be due to uncertainty as to the sense in which a particular word is used or to faulty construction of a sentence.

In the case of individual words the doubt may affect the general meaning. For with the course of time even general meanings may change, often by some one class of occasional meanings displacing all others, or by new occasional meanings being adopted. Such changes are continually going on in every living language, though the existence of written and printed literature enormously retards the process. At any one period it may be doubtful how far the change has gone. Such a question cannot be determined by etymology or by appeal to former usage. As Dr. Bosanquet says, “a word means what it is used to mean, not what it once meant.”¹

Sometimes the difficulty is increased by the older meaning lingering on in one special department of thought and knowledge. De Morgan gives a good example: “The word *publication* has gradually changed its meaning, except in the courts of law. It stood for *communication to others* without reference

Ambigui-
ties of
Language.

Ambigui-
ties in
Individual
Words.

¹ *Logic*, vol. i, p. 52.

to the mode of communication, or the number of recipients. Gradually, as printing became the easiest and most usual mode of publication, the word acquired its modern meaning ; if we say a man publishes his travels, we mean that he writes and prints a book descriptive of them. I suspect that many persons have come within the danger of the law, by not knowing that to write a letter which contains defamation, and to send it to another person to read, is *publishing a libel* ; that is, by imagining that they were safe from the consequences of publishing, so long as they did not print.”¹

But when ambiguity arises from individual words it is generally due to doubt as to which of various current meanings is intended. Such instances of ambiguity are especially common in the sciences which deal with man's life. These naturally have very few technical terms, but use the words of common speech with all their vast flexibility of meaning. The door is thus opened wide to misconceptions of meaning. A writer intends to use a word—say such a term as ‘money’ or ‘value,’ or ‘motive’—in one sense, and is, it may be, careful to state his intention explicitly. But his reader may forget this limitation and read another sense into the word, and so misunderstand him. Indeed, words which are used in widely differing senses are a pitfall to the writer himself. He is liable when using such a term in one sense to make assertions or to draw inferences which are only justified when the term is used in another sense. For example, when ‘money’ is said to be ‘scarce’ in the money market, the meaning is that there is a scarcity of capital seeking investment. To infer from this that the coinage of gold and silver coins

¹ *Formal Logic*, p 243.

should be increased is to be misled by the fact that in another meaning 'money' is limited to such coinage. But 'scarcity of money' in the former sense is by no means the same thing as 'scarcity of money' in the latter sense, and has no necessary connexion with it.

Another ambiguous word is 'government.' Suppose we are asked whether it is ever lawful to resist the government. Our answer must depend upon whether by 'government' is meant the system of laws established in a nation or the body of men charged with carrying out those laws. It may happen that the government in the latter sense is trying to subvert the government in the former sense. In that case, in whichever way a man acts, he resists the government in one of the two senses of the word, and what is loyalty from the one point of view is disloyalty from the other.

'Nature' is another very ambiguous word, and particularly so when used in the attractive phrase, "education according to nature." This has meant very different things with different writers. With Comenius it meant that educational method should be based on more or less fanciful analogies with processes in the physical world. For example: "The sun does not occupy itself with any single object, animal, or tree; but lights and warms the whole earth at once. . . . In imitation of this there should only be one teacher in each school, or, at any rate, in each class."¹ Rousseau first made the phrase really fashionable. With him and his followers it meant that the educator should mainly look on, whilst the child follows his innate impulses. The perfection of manhood was held to be discoverable

¹ *The Great Didactic* (Keatinge's Translation), pp. 315—316.

only in "the noble savage," before the dawn of civilization had corrupted humanity. A similar thought underlies the excuse so frequently given for not checking childish faults, that they are 'natural.' On the other hand, Plato and many modern thinkers regard man's true nature as the ideal perfection towards which all advance in real civilization is a slow and toilsome struggle. They seek true human nature in the end of man's development, not in the beginning of it. With them "education according to nature" means guiding the child along the path of this development as far as his capacity will allow. It is evident that such opposed interpretations of the one phrase will lead to very different educational systems.

No words cause more ambiguity than pronouns, because their reference is always decided nearly entirely by the context. Any number of examples can be culled from even our best writers. For instance, Steele writes: "When a man considers the state of his own mind, he will find that the best defence against vice is preserving the worthiest part of his own spirit pure from any great offence against it,"¹ where the reference of "it" is by no means clear.

A great daily newspaper, in describing the attempts made to discover the robbers of a large sum of money from a London bank, told its readers "The bank is well guarded. Officials are specially employed to watch all transactions from places where they are not seen."² If the reference of "they" is to be decided by grammatical rules, the authorities who placed the officials would seem to have acted with much unwisdom. But probably the writer did not mean what he said.

¹ *Guardian*, No. 19.

² *The Daily Chronicle*, January 26th, 1899.

Not nouns and pronouns only, but any part of speech is liable to be ambiguous. Swift speaks of "the Reformation of Luther," where the "of" is probably meant to be equivalent to "by." In the *Spectator* we read "I have long since learned to like nothing but what you do," where the ambiguity of the last word is very apparent. The dentist who advertised: "Teeth extracted with great pains," was not only ambiguous in expression, but—probably unconsciously—humorous.

An important cause of ambiguity is the fact that words such as 'all' and 'some' can be used either collectively or distributively. "I can move all those books," may be true if they may be moved in succession, but false if they are to be moved in a body. The spendthrift argues "I can afford this, *or* that, *or* the other," and draws the conclusion that he can afford them all collectively, to the ultimate grief of his creditors. On the other hand, the miser is prone to urge that because he cannot afford to subscribe to *all* the socially useful institutions that beg his help, he therefore cannot afford to subscribe to *any*. Schools are especially liable to suffer from false inferences due to ambiguity of this kind. Many excellent people see in the study of some particular subject a sovereign cure for all educational ills, and urge the inclusion of that subject in the curriculum of every school. Unhappily each doctor has a different quack remedy, and though time and energy might be found for including *any one*, yet the attempt to include *all* leads only to disaster. However, each reformer urges that room can be found for his own pet subject, and the educational lawgivers are too apt to yield in every case, through looking at the question piecemeal instead of as a whole.

Misconception or doubt as to meaning arises even

Ambigui-
ties in Con-
struction.

more frequently from clumsily constructed sentences than from doubt as to the meaning of individual words. Indeed, the former is the common cause of the latter, as is apparent in the few examples we have given, and as might be expected from the fact that alteration in the meaning of a word is mainly a matter of context. In an analytic language like English the meaning depends on the order of words much more than in a synthetic language like Latin. Ambiguity is frequently due to want of care in locating words and phrases. Here again numerous instances can be found in even the best writers. Says Swift in *Gulliver's Travels*, "It contained a warrant for conducting me and my retinue to Traldragdubb or Trildrogdrib, for it is pronounced both ways, as near as I can remember, by a party of ten horse," where we get at the meaning only by mentally transposing the last phrase, on the assumption that the writer must have *meant* something different from what he *said*. In his translation of Homer's *Odyssey* Pope tells us "And thus the son the fervent sire addressed," which is as ambiguous as is the line "The noble hound the wolf hath slain" in W. R. Spencer's poem *Gelert*. "An instance of [ambiguous construction] maybe read on the walls of Windsor Castle—'Hoc fecit Wykeham.' The king was incensed with the bishop for daring to record that he made the tower, but the latter adroitly replied that what he really meant to indicate was that the tower was the making of him."¹ In the *Tatler*, Steele writes "He had by some strange magic arrived at the value of half a plumb, as the citizens call an hundred thousand pounds,"² leaving his readers to wonder whether the sum mentioned was, in the slang of the day, "a plumb" or "half a plumb." Many ambiguous constructions are uncon-

¹ Stock, *Deductive Logic*, p. 303.

² *Tatler*, No. 40.

sciously humorous. Perhaps as good an example as could easily be found was furnished by a pushing shopkeeper in one of our great northern towns who exhibited in his window, to the joy of all beholders, a placard bearing, in all the emphasis of large type, the legend "Why go elsewhere to be cheated? Come in here!"

The haste in which much modern writing is done, especially for the daily press, causes many such slipshod sentences to be continually presented to the reading public. The natural result is that carelessness in expressing thought spreads, and we have continually to "read between the lines" to get at an author's meaning. Doubt has, indeed, been expressed whether the majority of Englishmen ever either say what they mean or mean what they say. This is undoubtedly much to be regretted. When the close connexion of speech and thought is considered it becomes evident that looseness of expression is sure to react more or less on thought. Indeed, it is continually found that ambiguities such as we have been considering are the root from which spring many of the fallacies, or erroneous interpretations and inferences, which meet us on every hand. The educator can engage in few more useful tasks than that of training his pupils to clear and exact expression of meaning.

CHAPTER IV

KNOWLEDGE AND LOGIC

Nature of
Logic.

§ 1.—KNOWLEDGE, as we have seen, can only include beliefs of mankind which are true, that is, which agree with reality; in knowledge, belief is in harmony with fact. But to say this would be without meaning if we were unable to distinguish genuine from apparent knowledge. To say we 'know' therefore implies that we can know that we know; in other words, that knowledge itself can be an object of knowledge. And this is possible because knowledge is a part of reality; it is an important factor in the one universe, or totality of existence, which is the object of all knowledge. If, however, it is possible to distinguish knowledge from mere belief, there must be certain general conditions which are found in all cases of knowledge, and are absent from all cases of mere belief. The investigation of these conditions is the province of logic.

Again, we have seen that knowledge itself is in a state of continuous growth and development, and that the knowledge of mankind is both the product and the corrective of the knowledge of individuals. In order to examine the nature of knowledge, then, it is not sufficient to study the structure of the whole of

knowledge as it is, it is necessary also to enquire into the conditions of its growth and development, both in the individual and in the race. Just as botany considers not only the structure but the growth and development of plants, and geology investigates not only the nature of the earth's crust but the processes which have given to that crust its present form, so *Logic is the science which investigates the origin, development and structure of knowledge.*

§ 2.—All knowledge and all belief exist in the form of judgments or assertions. The assertion may be merely mental, and it need not be fully and explicitly set out in words. But every attempt at interpreting experience is an assertion or judgment of some kind; for, as has been shown in the preceding chapters, it is a reference of an idea to reality, and such reference is exactly what is meant by judgment or assertion. It follows that judgments are of varying scope, corresponding to the different extent of the ideas or systems which represent our mental construction of reality. From the widest of all possible judgments, which asserts the universe as a systematic whole, to the interpretation of a simple present experience, such as "it rains" or "I have a toothache," the gradations are innumerable, but the difference of scope does not affect the essential character of the mental act.

Nature of
Judgment.

§ 3.—Now, about every assertion the fundamental questions to be asked are: What does it mean? On what evidence is it based? Is it true? On the answers which can be given to these questions in any particular case depends the decision whether the judgment in question is to be admitted as a piece of knowledge.

Judgments
and Logic.

It is not, however, with the meaning and truth of this or that particular judgment that logic is

concerned, but with the conditions of the validity of judgment in general. Whether those conditions are fulfilled in any particular case must be left for decision to that branch of science which enquires into the special subject-matter with which the judgment deals. Hence it is about judgments in general that logic asks the questions which the special sciences ask about particular judgments.

Abstract
Nature of
Thought.

§ 4.—This makes it plain that logic is a very abstract science. All science, indeed, is abstract, for each science is the construction of reality from one special point of view. It is only by approaching reality now from this side, and now from that, that human thought can deal with it at all. "The mind, with all its powers, is incapable of grasping the whole even of the 'flower in the crannied wall.'¹ It deals with it first under this aspect, and then under that—as a thing of beauty, as suggestive of a Wordsworthian sonnet, as injurious to the structure of the wall, as a *Composita*, as consisting mainly of carbon, oxygen, hydrogen, and nitrogen in certain proportions, as decomposing so many cubic feet of carbonic acid per diem under the influence of sunlight. And whichever aspect we like to take we are pretty sure to leave out the rest. The sonnet would be deranged by a thought of the carbonic acid. And yet somehow all these aspects belong to the flower. The whole, which is the real, contains or presents them all and many more. And so we learn our first lesson about thought, that to grasp anything at all we must leave out the greater part of it. . . . We must admit that the mind never yet sifted out a grain of truth without letting twenty other grains slip past unnoticed."²

¹ Cf. p. 19.

² Hobhouse, *The Theory of Knowledge*, pp. 6–7.

To know even the smallest piece of reality at all thoroughly, we have, then, to think it successively under a great number of general ideas, each of which includes under it a vast number of other particular facts. Every general idea is thus the expression of a relation binding together a vast number of individuals; it is the universal identity which exists amidst the particular differences of the individual facts. Each general idea is also related to other general ideas dealing with similar aspects of reality, and thus we get those organized systems of knowledge which we call the 'sciences.' It is evident, then, that every fact may be considered from the point of view of many sciences, each of which deals with it from one side. This is just what is meant by saying the fact is *concrete*, and the science *abstract*. The concrete means simply the embodiment of a number of general qualities or relations; the abstract means simply the selection of one of those aspects and the exclusion of the others.

§ 5.—This distinction is closely connected with that between *form* and *matter*. The simplest example of 'form' is the shape of a material object, say a statue, whilst the 'matter' is the marble, bronze, or other material of which it is composed. Here we see at once that the form is the creation of man's mind; it is that which gives artistic value to the statue, indeed, that which makes it a statue at all as distinguished from a mere block of stone or metal. This, however, is only a first application of the terms. Further thought shows that the same distinction can be applied throughout. "There is no matter without form . . . In a knife the matter is steel, the form is the shape of the blade. But the qualities of steel again depend, we must suppose, upon a certain character and arrangement in its particles, and this is, as

Form and
Matter.

Bacon would have called it, the *form* of steel. But taken as purely relative, the distinction is good *prima facie*. Steel has its own form, but the knife has its form, and the matter steel can take many other forms besides that of a knife. Marble has its own form, its definable properties as marble (chemical and mechanical), but in a statue, marble is the matter, and the form is the shape given by the sculptor.”¹ Similarly, we may say that a mathematical formula is the form, of which the particular examples which come under it are the matter.

But just as there can be no matter without form, so there can be no form without matter. Nor is the form independent of the matter. Many forms which can be expressed in gold cannot exist in clay, in sand, or in water. The form each material can take is partly determined by its own nature, and is one way in which that nature is expressed.

Logic is
Abstract
and Formal.

§ 6.—The ‘form’ then of any piece of reality consists of the general abstract qualities and relations which it exemplifies. Thus every science deals with one particular ‘form,’ or kind of qualities and relations, and the more general those qualities and relations are the more emphatically ‘formal’ is the science. Thus, mathematics is one of the most formal and abstract of sciences, as it deals with an aspect of all things which can have quantity. But logic is yet more formal, as it deals with the form of all knowledge, that is with those most general conditions which differentiate knowledge from what is not knowledge. As each science neglects every aspect of reality but one, so logic neglects all aspects of actual knowledge except those which belong to it simply as knowledge, irrespective of the reality which is known. It deals “not with the results of knowledge, but with the

¹ Bosanquet, *Essentials of Logic*, p. 43.

outline plan upon which these results may ultimately be put together."¹

Thus, logic has to find its subject matter, not in the external world of sense-experience, but in the world of thought. Its subject matter is, in a sense, not new; for in studying knowledge we are necessarily dealing with the same objects of knowledge with which we deal in other sciences. The difference is that in the other sciences we deal with these objects as they are in themselves and in relation to each other, whilst in logic we deal with them merely as examples of how we know, that is, in a certain relation to our own minds. In this logic resembles psychology. But in logic the emphasis is laid on the knowledge, whilst in psychology it is laid on the mind. In other words, logic is concerned with the validity of the thought, psychology only with the manner of its occurrence.

§ 7.—But though logic considers the validity of thought it is not its function to teach men how to reason. Function
of Logic. "Men reasoned generation after generation long before they knew a single dialectical rule. . . . The principles of logic were operative in every ratiocination, yet the reasoner was incognisant of their influence until Aristotle anatomized the process."² And nowadays men reason—and often reason well—who have never studied logic. Logic, in other words, does not lay down laws for thought, it does not set itself up to decide what methods of investigation will lead to truth. In the Middle Ages logic pretended to do this, with the result that during the centuries when men accepted its guidance, knowledge made scarcely any advance. The logician nowadays is more modest. He sees that his province is to accept as valid all methods which lead to an increase

¹ Hobhouse, *op. cit.*, p. 10.

² Ferrier, *Institutes of Metaphysic*, p. 15.

of knowledge, and to analyse them, so as to find out what is essential and what is accidental in them. Nor does he claim to dictate to the future. For just as sciences like botany and geology can speak with much more certainty of the form which development has taken up to the present than of the form it will take in the whole range of the future, so it is with logic. The logician can analyse the processes which have led to knowledge in the past, and are leading to knowledge in the present, but he must not attempt to limit the activity of thought by saying that those processes are the only ones which can ever lead to knowledge.

Value of
Logic.

§ 8.—The purpose of logic is, then, to make clear and explicit the principles and the character of valid thought; of thought, that is, which attains knowledge. And in this is its value. The person who has not studied logic has generally never made clear to his own mind the conditions which determine the accuracy of his inferences. Many a man “infers, but can give you a very poor account of the grounds of his inference. He may, even so, infer well, in which case he is a person of insight, tact, skill, wisdom, but not a reasoner, nor one who understands the logical connexion of things. The practical mark of such a person is the irregularity of his success in inference. He reasons well when he has great experience or some natural gift, but apart from that he flounders. A logical mind is slower but surer.”¹ The study of logic aids in the cultivation of the logical mind, though it will not ensure its development. By making clear the principles on which correct thought proceeds, logic indirectly helps the production of correct thought, for those principles can be consciously accepted as guides.

¹ Hobhouse, *op. cit.*, pp. 237—238.

CHAPTER V

NATURE OF JUDGMENT

§ 1.—WE have seen that every piece of knowledge and of belief exists in the form of judgment or mental assertion, and further that about every judgment we should ask the three fundamental questions as to its meaning, its truth, and its justification.¹ We have now to deal with the first of these questions in that general way in which alone logic is concerned with them. We have to enquire what is involved in the act of judgment as such, and what, consequently is implied by every judgment, no matter what the subject is with which it deals.

Judgment
and
Proposition.

In entering on this enquiry it must be borne in mind that it is judgment as a mental act, and not the proposition, or form of words in which it may be expressed, with which we are primarily concerned. We can only consider judgments when they are verbally expressed, but this expression is very often imperfect, and in such cases we must go behind the proposition to find the true judgment, and having found it we are at liberty to express it in another verbal form if in that way we can state

¹ See p. 63.

the real meaning more clearly. Logic, indeed, postulates that expression must be adapted to thought. Of course, we only know the judgments of others through the propositions in which they are presented to us, but we can frequently see that the verbal presentation does not precisely coincide with the judgment it is intended to express. We have, then, to interpret the verbal expressions of other people's thought just as much as other pieces of our experience. Sometimes, no doubt, our interpretation is wrong, and then the judgment conveyed to our mind is different from that which existed in the mind of the speaker or writer from whom we received the proposition, and we have a case of misunderstanding.

Having decided what judgment a given proposition conveys, we must either accept it, reject it, or be in doubt about it. In the last case we do not ourselves judge at all; we suspend judgment. But both when we accept and when we reject a proposition offered us by another, we ourselves perform an act of judgment. In the one case we adopt the suggested judgment as our own; in the other case in rejecting the suggested judgment we of necessity accept its contradictory; if, for example, we reject the judgment that war is sometimes necessary we by that very rejection mentally affirm—*i.e.*, we judge—that war is never necessary.¹

Judgment
and Truth.

§ 2.—This has led us to one essential characteristic of judgment as a mental act; it always claims to be true. It is impossible for any one to judge what he believes to be false. Any one judgment may of course be actually untrue; but it cannot appear untrue to him who makes it at the moment when he makes it. A judgment, then, may be a truth or a

¹ Cf. p. 29-30.

falsity, but it cannot be a falsehood. A proposition may, of course, be a falsehood, and it may even be a falsehood when it is true, for he who utters it may believe it to be false and so to him it is a falsehood. But this is an ethical and psychological consideration, not a logical one. Logically we are concerned, not with whether a person who makes a statement actually believes it, but with whether it is in reality true or false. The question of intention has no interest for logic, but only the question of actual truth or falsity; and this is a question which applies to every judgment and to every proposition.

This claim to truth makes it clear that every sentence is not a proposition. A sentence may express a command, a wish, or a question. But to command or to wish a thing does not necessarily make it true or real—"If wishes were horses, beggars would ride." However, the command or the wish exists truly enough in the mind, though its accomplishment may never become a reality in the world of hard fact. Hence, every command or wish may be taken as an indirect expression of a judgment concerning the desires of him who makes it; for instance, "Come here, John," is an indirect way of expressing the judgment "My wish (or intention) is that John should come here." Similarly, a question is not a judgment; indeed it indicates the absence of the power of judging in some particular about the matter with which the question deals. But indirectly it may be taken to express a judgment as to the mental state of the questioner—the judgment that he is ignorant and desires information on a certain point.

Further, nothing but a judgment can be true or false. We say sometimes "Nothing can be truer than fact," but by fact we do not mean simply an occurrence in the external world but such an occurrence as

known ; *i.e.*, as judged. The occurrence simply *is* ; it is the judgment about it which is true or false.

Judgment
and Ex-
perience.

§ 3.—Whenever we judge, then, whether our judgment is original or whether it is the acceptance of a judgment offered us by another, we assert what we believe to be true. And such assertion is not arbitrary, it has behind it what seems to us a sufficient ground—a ground which would compel any other rational mind to make the same judgment. The question of when such ground is really sufficient will occupy us in future chapters : we only point out now that to judge without any grounds is impossible to a rational mind.

Of necessity, the grounds for every judgment must be found in the apprehended nature of that with which the judgment is concerned. To say a judgment is true is to say it represents reality. But, as we have seen, reality exists for man only so far as he is aware of it ; he interprets it in the form of judgment and in that form only.¹ Every separate judgment is, then, an attempt—believed at the time to be a valid attempt—to mentally reconstruct reality, that is, to construct in our thought a system corresponding to actual existence. Every such attempt is occasioned by some experience, for it is only in experience that reality is known. Every piece of experience must be interpreted, or made intelligible, before it can take its place in our system of knowledge. Such interpretation harmonizes that experience with the system of knowledge already existing and derived from other experiences, either of ourselves or of others.

But our systems of knowledge exist in the form of ideas.² Interpretation of any experience is, then, the bringing it under some idea, that is, the seeing it as an example of the general nature or law which that

¹ Cf. pp. 27, 63.

² Cf. p. 42.

idea embodies. It must not be forgotten, however, that the idea is itself a part of reality and is derived from the reality it more or less truly represents. Ideas are not made by the mind outside of experience and independently of reality. Their content is found by us in reality; but found by thought and not by the exercise of the senses of seeing, hearing, &c. Experience is the whole of mental life, and includes our interpretation of what comes to us through the senses as well as those sense-impressions themselves. If we remember this, then we can truly say that all knowledge is experience, but if we make the very common mistake of limiting "experience" to sense-impressions, then such a statement becomes absolutely absurd, for sense-impressions are not knowledge at all, but only the materials out of which the mind makes knowledge.

§ 4.—In every judgment, then, we interpret some piece of experience by referring it to an idea derived from previous experiences. But the piece of experience we interpret is never the whole of our experience at the moment; it is some element in that whole selected by attention. If I say, "This room is too warm," I am fixing attention not merely upon my space surroundings, but upon one aspect of those surroundings, and by so doing I am neglecting the rest. There are other aspects of the room besides its temperature to which I could attend, but I am led by my feelings, or by some purpose, to attend only to the warmth. The judgment is, then, an act of analysis, or of selection of some elements out of a totality to the neglect of the rest. In other words, the judgment actually made is only one of a large number of judgments which could be made about the room; "warmth" is only one of the ideas under which it could be regarded. Every judgment, then,

Judgment
is an act
of both
Analysis
and
Synthesis.

is merely a partial interpretation of experience ; we can only master reality bit by bit.¹

The judgment is an act of analysis in a further sense. The too high temperature is one experience which forces itself upon my attention. When attended to, it is resolved into the two ideas of the temperature of the room, and of excessive warmth as a quality of that temperature. It is the actual room-temperature which is experienced by the senses ; its effect on me is explained by bringing that temperature under the idea of excessive warmth. So in every case. We see a bird flying, and the bird and its flight are one and the same experience, and the judgment which expresses that experience is one simple act of thought. But it is an act which analyses the experience into the two elements of bird and act of flying, and asserts that the latter is true of the former.

This is, however, only one side of the truth. Each of the two parts into which a judgment analyses an experience has a meaning by itself, and these meanings are not identical with each other. We can think of birds in many other acts besides that of flying ; and we can think of flying as the movement of kites and arrows as well as of birds, or of other birds besides this particular individual. The judgment is an act of synthesis, or building up, as well as an act of analysis, or taking to pieces. The two general ideas of bird and flight are thought together and modify each other.

Every judgment is, then, an act both of analysis and of synthesis. The fact that judgments can only be examined in the form of propositions tends, however, to cause the analytic aspect of the act to be overlooked. For the proposition is composed of words, each of

¹ Cf. p. 64.

which is a separate element in that proposition, and these words must be both produced and received successively. Hence there arises a tendency to regard a judgment as a synthesis only. Because in the proposition "The bird flies" the words "the bird" must be both uttered and heard before the word "flies," and because he who hears the statement must gather its meaning by putting together these two ideas, it is assumed that this is a sufficient account of the judgment. But it is not so. The judgment originated in the analysis of an act of perception, and when it is communicated to another, it only becomes a judgment to him when the whole is grasped, so that the elements are no longer separate but are seen as connected in that whole, and, therefore, stand before the mind as the results of an analysis of that whole. It must be always borne in mind that the proposition or verbal statement is only instrumental to the judgment, and that in the latter the two essential parts, though they are distinguished, are not separated as are the words in a sentence.

§ 5.—We have, then, two essential parts in a judgment, and these are called the *Subject* and the *Predicate*. The same two terms are used in grammar, but the grammatical subject is not always the logical subject. By the latter is meant that part of the experience interpreted from which the thought starts; and by the logical predicate is meant that further movement of thought which makes the experience more explicit. In isolated judgments it is frequently impossible to say with certainty what is the logical subject. Take the sentence "This is an orchid." This may be an answer to an enquiry as to which of certain plants is an orchid, when the subject would "an orchid," and the predicate would be the indication of a particular flower, this indication

Subject and
Predicate.

being verbally represented by the word "this." But on the other hand the same sentence may be an answer to the question "What is this flower?" and in that case the "this" represents the subject, for it is the starting point of the thought, and "an orchid" is the predicate, for it is the further filling out of that thought. Similarly, the limits of the logical subject depend on what is already known. "If you say, 'He is going down to Yorkshire to-morrow by the 9.45 from King's Cross,' you divide 'he' as the grammatical subject from the rest as predicate; but the real transition in thought is from what we knew before to what the judgment tells us, and on this principle we might divide the judgment at any point, and should do so if we wish to represent the character of the advance, according to the interest which the statement satisfies—'He,' or 'going,' or 'Yorkshire,' or 'the 9.45' or 'King's Cross,' may be the real predicate, the real addition to what we knew before."¹ This shows that the actual determination of subject and predicate in any case is psychological. There is always a logical subject and a logical predicate, but these are not fixed elements. "The content of the judgment is a complex of interconnected elements, any one of which can stand as subject or as predicate to the rest."² It is evident, then, that the 'grammatical subject'—that is, the nominative to the principal verb—cannot in any proposition be taken, without further enquiry, as the logical subject. But yet, as speech should express thought with the greatest possible exactness, judgments are most adequately represented by propositions in which there is this coincidence, so that, as Dr. Bosanquet puts it: "I think that to ask whether the grammatical corresponds to the logical subject is

¹ Hobhouse, *The Theory of Knowledge*, p. 156. ² *Ibid.*

only to ask whether we have said what we meant to say." ¹

§ 6.—We have, however, yet another element of the proposition to examine. Logic prefers to express judgments by propositions in which subject and predicate are separated by the verb 'is' or 'are,' with or without the negative 'not.' Thus, the form "Gold is lustrous" would be preferred to the form "Gold glitters." This additional element in the expression of a judgment is called the *Copula*, and always consists of the present tense of the verb 'to be.' Now the word "copula" suggests the idea of a link joining two independent ideas; and then the analytic aspect of the judgment is lost sight of. So fully is this sometimes done that Mr. Swinburne in his *Picture Logic* represents subject and predicate as two railway carriages, and the copula as the coupling chain attaching them to each other.² "This," as Dr. Bosanquet remarks, "is an excellent type of the way in which we should *not* think of it."³ The copula is, indeed, not an independent element of the judgment at all, and its function in the proposition is only to indicate that the act of judgment has really taken place. "Benno Erdmann has strikingly expressed this point of view by saying, that in the judgment, 'The dead ride fast,' the subject is 'the dead,' the predicate 'fast riding,' and the copula 'the fast riding of the dead.'"⁴

The copula is, then, a sign of judgment; it is not a mere link joining two independent elements; it does not add on to the subject a new idea which had previously no connexion with it, but it declares

¹ *Knowledge and Reality*, p. 183.

² *Picture Logic*, p. 173.

³ *Essentials of Logic*, p. 100 (note).

⁴ Bosanquet, *op. cit.*, p. 100.

that subject and predicate are connected elements in one whole which the act of judgment has analysed. It is, therefore, a sign of both that analysis and synthesis which are aspects of every judgment.

Relative
Prominence
of Analysis
and Syn-
thesis in
Judg-
ments.

§ 7.—Though every judgment is both an analysis and a synthesis, yet either of these aspects may be the more prominent. It all depends upon whether the thought starts from the whole, and proceeds to make explicit the relations of the parts within that whole, when the analytic aspect is the more prominent; or whether it starts from the parts as distinct and proceeds to bring out their connexion with each other, thus constituting the whole, when the synthesis is the more apparent. Simple examples can be found in such judgments as $8 = 5 + 3$ where the analysis is the more prominent; and in $5 + 3 = 8$ where the synthesis predominates. The fact is the same in each case, though the ways of approaching it are different; and reality is not affected by the way we state it. This question, however, cannot be fully discussed at this stage; all we would insist on now is that, as in each case both a whole and its connected parts enter into the judgment, and as they are distinguished but not separate in the act of judging, so in each case the judgment is both an analysis and a synthesis.

Summary.

§ 8.—If now we sum up the results we have reached in this chapter, we may say: That judgment is coextensive with affirmation and denial; that every judgment is a truth or falsity, but from its very nature claims to be true; that truth means correct interpretation of the reality given in experience; that every judgment is a single act of thought, and is both analytic and synthetic, though one of these aspects may preponderate; that the copula is not a link joining separate ideas, but is a sign that subject

and predicate have been distinguished as connected elements in a given whole ; that the distinction of subject and predicate is not a fixed one, but is relative to the actual work of thought in the judgment ; that the proposition should be as exact a verbal presentment of the judgment as possible.

CHAPTER VI

TYPES OF JUDGMENT

Main Types
of Judgment.

§ 1.—A COMPLETE enumeration of the forms of verbal statement in which judgments are expressed is obviously impossible, and even were it made it would be of rhetorical rather than of logical interest. But an enumeration of the main types of judgment is a much simpler matter, and, as was said in the last chapter, it is the judgment with which logic as a theory of knowledge is primarily concerned. Logic deals with the proposition only as expressive of a judgment, and is, therefore, justified in reducing the multitudinous forms of statement of ordinary speech to a few typical forms, so long as these forms are capable of expressing all essential differences in the mode of judging.

There are, as was seen in our earlier chapters, three main stages in the organization of knowledge—the stages of perception of things, of appreciation of universal relations, and of conception of system. Of course, in the totality of the knowledge of each one of us individually, and of mankind as a whole, we can find examples of each stage. In some domains we are in the last stage, in some in the second, and in

others only in the first. Corresponding to each stage is a typical form of judgment. There is first the *Categorical Judgment*, or judgment of fact, such as "This ink is black," or "All these boys have passed the Cambridge Local Examination." Secondly, there is the *Hypothetical Judgment*, the typical judgment of universal relation or law, such as "If water is cooled to a temperature of 32° F. under the pressure of one atmosphere, it freezes." Thirdly, there is the *Disjunctive Judgment*, or typical judgment of system, as "Triangles are either equilateral, isosceles, or scalene." Stated thus, these seem to be strictly marked off from each other by their form. They are, however, only typical forms, and as knowledge makes no sudden jump from one stage to another, but develops gradually, so the judgments in which knowledge is expressed merge gradually into each other. Especially is this the case with the categorical and hypothetical judgments, as might be expected from the fact that the same analysis of reality which gives us exact knowledge of individual things makes plain the relations of those things to others.

Further, we have the distinction between affirmation and denial, the force and extent of which we shall have to examine.

§ 2.—We have now to trace the development of these types of judgment from the simplest forms, and to show their relation to each other. We will trace this development first in the affirmative forms, and then consider the meaning of the negative forms.

The simplest cases of categorical judgment are those *Impersonal Judgments* which express the general character of a nearly entirely unanalysed mass of present experience. They arise out of a mass of vague feeling, and analysis has only proceeded so far as to determine its general character. Such judg-

Develop-
ment of
Judgment—

*Impersonal
Judgments.*

ments are exemplified by the "It hurts" or "How nice!" of the child. Here the logical subject is the undifferentiated mass of present experience, and the whole force of the judgment practically rests in the predicate. We make similar judgments throughout life, e.g., "It rains," "It is foggy," where the "it" which indicates the subject has the vaguest kind of general reference to the weather experiences of the moment.

Demonstrative Judgments.

Closely allied to these are judgments which may be called *Demonstrative*, as they indicate, though they do not necessarily name, the element of reality which they interpret. In these cases there is frequently no formulation in words at all; a demonstrative judgment is implied in the very simplest act of recognition. When such a judgment is explicitly stated in words, the logical subject is generally represented by some such demonstrative word as 'This,' 'That,' "Here," 'Now,' as when one might say "Here is London," "This is an orchid," "Now's the day and now's the hour."

When the analysis has been carried a step further, the new movement of thought starts from the result of such a judgment as we have just considered. The whole result of this judgment will now form the subject, and the new judgment will take such a form as "This book is very interesting"—which obviously assumes the judgment "This is a book."

Judgments of Particular Relations.

A further step in complexity is taken in what may be called the *Judgment of Particular Relation*, as "Brighton is to the south of London;" "This book is heavier than that." In such cases the analysis of experience is deeper, and has given us two terms and the relation between them.

So far the judgments we have considered deal primarily with facts in present perception, though in asserting the predicate of the subject they necessarily

pass beyond present perception and bring in an idea derived from previous experiences. In the last two examples, moreover, the subjects also have a reference beyond the present, as "this book," "London," and "Brighton," are thought as having a continued existence.

More obvious still is this growing width of reference when the judgment is of what we may call a historical character, as when we say, "Cæsar conquered Gaul." Here the proper name represents a person, who did many actions which are united into that whole which we call a life by the fact that they were the actions of one individual. The personality is, therefore, a universal, or factor common to all those actions, and they are the different expressions in which the character of that universal becomes manifest. Such a judgment has, then, both an individual and a universal character, and it forms a kind of transition between the purely categorical judgments of fact and the judgments of universal relation or law which mark the next stage of knowledge.

*Historical
Singular
Judgments.*

But the aim of thought is to reach universal judgments, that is, judgments which hold true of all cases of a similar kind. The first step in this direction is taken when a present experience is found to agree with a number of remembered past experiences. Hence arise all *Judgments of Enumeration*, such as "My holidays for the last five years have been spent in Devonshire." In such a judgment there has been a synthesis of remembered experiences with present experience. When the remembered experiences have been all alike, we can sum them up in the word "all," as when one might say "All my attempts to pass examinations have been successful."

*Enumerative
Judgments.*

But memory construction, even when we take it

*Search for
the Universal
Judgment.*

in its widest sense as including the memories of the whole human race, can carry us no further; it can never justify us in making assertions which pass beyond experience. How then are we to reach such a truly universal judgment as "All cows eat grass"? From our observation, even when supplemented by the testimony of others, we cannot be justified in asserting more than "Some cows eat grass," for it is certain that cows not yet born have not been observed, to say nothing of innumerable cows in the past, and perhaps in the present, that have lived outside the observation of man. And it is equally certain that our judgment covers all those cows. No doubt uniformity of experience, especially when that experience is very extended, gives us a strong presumption in favour of universal agreement. But such presumption is not a logical justification; it strengthens belief, but does not convert it into knowledge. Before the discovery of Australia, uncontradicted experience justified the judgment "All swans hitherto known are white," but had the really universal judgment "All swans are white" been made, the black swans of Australia would have proved it to be unjustified.

Mere observation, then, however extended it may be, can never give logical justification for a really universal judgment. Such justification is always a matter of inference, and is the work, not of sense-experience, but of thought. Suppose a beginner in geometry has found that if he inscribes a triangle in a semi-circle, the angle which touches the circumference is a right angle. He has certainly no reason for thinking that any triangle which he might inscribe in any semi-circle would exhibit the same characteristic. The idea that this might be so would possibly suggest itself to him, and would

be likely to do so if he inscribed several triangles in semi-circles and found that each had a right angle touching the circumference. But the number of triangles that could be inscribed in any one semi-circle is infinite, and the number of possible semi-circles is also infinite, and no amount of experience in drawing diagrams and measuring angles could ever include them all, and so justify the judgment "Every triangle inscribed in a semi-circle has a right-angle touching the circumference." It is only when by inference from the known nature of semi-circle and triangle he has proved that this judgment must be true that he is justified in asserting it.

What is true in this case is true in every case. *The Generic Judgment.* The universal judgment of the general form "Every S is P" is true only because something in the nature of the reality the judgment interprets makes the conjunction of S and P a necessary one. True universality is a consequence of necessity. This necessary connexion of content is better expressed in the *Generic Judgment*, the general form of which is "S as such is P."

But when we reach this point we have passed beyond mere judgment of fact. The generic judgment is at once concrete and abstract. It is abstract in that it asserts a universal connexion of content without direct reference to the instances in which that connexion may be exemplified in reality. But it is concrete in that it assumes there are such instances, and so justifies the universal categorical judgment "Every S is P."

If we develop the abstract side of the Generic Judgment we reach the *Hypothetical Judgment*, *The Hypothetical Judgment.* the general form of which is "If S is M it is P." The generic judgment implies that there is something in the reality interpreted by it which makes

the connexion of S and P a necessary one. The hypothetical judgment makes this condition explicit. We may say, "Water freezes at a temperature of 32° F," when we state a general relation as a fact. But this rests on the hypothetical "If water be exposed to a temperature of 32° F. it freezes," when the temperature is stated to be not merely coincident with the freezing but the essential condition under which it takes place. This challenges examination as to whether the statement of condition is adequate, and further analysis of the facts in this case shows that it is not, and that we must add "under ordinary atmospheric pressure," as a co-ordinate condition.

Whether a judgment of universal relation is stated categorically or hypothetically is, therefore, mainly a matter of convenience, determined by the purpose with which the judgment is enunciated. Which is the real nature of the judgment cannot be decided by its mere verbal expression. Often, indeed, a judgment which is essentially hypothetical is expressed by a proposition which is categorical in form, as in the familiar "Trespassers will be prosecuted." This would hold true even if there never were any trespassers, and so it never received realization in fact. For the actual judgment is "If any persons trespass they will be prosecuted," and the underlying reality which this judgment partially expounds is that system of law and law-courts which makes a prosecution for trespass possible.

In the pure categorical judgment the reference to reality is direct, and the judgment deals with the concrete facts of experience. In the generic judgment this reference to reality is indirect, in that it is implied rather than affirmed that instances exist which exhibit the connexion asserted. In the

hypothetical judgment this concrete reference disappears, and the judgment is purely abstract, and indifferent to whether the relation it asserts can be exemplified in real sensuous experience or not. The law of inertia, for example, asserts that, if all interfering conditions were removed, a motion once started would go on for ever. The fact that in the actual world of sense-experience perpetual motion can never be produced, because such interfering conditions as friction cannot be entirely removed, does not touch the truth of this law. Hypothetical judgments, then, do not directly express facts in the ordinary sense of that word; but indirectly imply them. "Underlying [such judgments] there is the implied categorical judgment, 'Reality has a character, such that, supposing so and so the consequence will be so and so.' And if this implied assertion is true, then the hypothetical judgment is true, although its terms may be not only unreal, but impossible. 'If a microscopic object-lens with a focal length of $\frac{1}{100}$ inch were used, its magnifying power with an A eye-piece would be so many diameters.' This is a mere matter of calculation, and is unquestionably true, depending upon the effects of refraction upon the optical image. But I do not suppose that such an object-lens could be made, or used."¹ In another way the judgment is highly abstract. Every such judgment deals with only one aspect of the reality it expresses, and many such judgments are necessary to express any whole concrete fact.

As the generic judgment finds a concrete expression in the categorical judgment of "allness" so the hypothetical judgment can be represented by what may be called the *Concrete Conditional*

¹ Bosanquet, *Essentials of Logic*, p. 123.

Proposition, whose general symbolic expression may be taken to be "Whenever any S is M that S is P," where the reference to cases in which the connexion is exemplified is much more direct. Of course this statement does not necessarily imply that real cases have ever been found, or even can be found, but the use of the "whenever" is misleading when no such cases are known to exist.

*Reciprocal
Universal
Judgments.*

Both the generic judgment, with its concrete expression in the universal categorical proposition, and the hypothetical judgment attain their most perfect form when they are reciprocal, that is, when not only does the predicate always accompany the subject, but when it is never found without the subject. In such cases it is also true that "Every P is S" and that "If S is P it is M." But without special proof, we can never assume that this is so. It is as true that every right-angled triangle can be inscribed in a semi-circle as it is that every triangle inscribed in a semi-circle is right-angled. Similarly, the 48th proposition of the First Book of Euclid is the converse or reciprocal of the 47th. But in every case such reciprocity has to be separately established; it is not implied by the original judgment.

*The Dis-
junctive
Judgment.*

The hypothetical judgment, then, explains the connexion of S and P by making explicit the condition M. But where, we may ask, are we to find a resting-place in our search for explanation? If the connexion of S and P is conditioned by M, we may equally ask for the element which is the ground of the connexion of S and M. So long as we keep to mere symbols there can be no stopping-point in this regress. But when we consider the matter with which any judgment deals we can find a resting-place, at any rate of a temporary character.

Ultimately, as was shown in chapter ii, explanation can be complete only when the whole universe is exhaustively known. Practically, however, we find sufficient explanation for our present purposes in seeing clearly the position of any fact or any law in one of those smaller systems into which, for our convenience, we divide the universe. To express the content of such a system is the function of the *Disjunctive Judgment*, whose general symbolic statement is "S is P, or Q, or . . . Z," where the number of alternative predicates is determined by the matter with which the judgment deals. Except in very simple cases it is obviously impossible to give concrete examples of such judgments. We may say "Graduation at the University of London is in either arts, science, law, medicine, or music," and, provided that the enumeration of faculties in the university is complete, this expresses the system in question. Similarly we express an arithmetical system when we affirm "All numbers are either prime or capable of being analysed into factors." Such judgments evidently rest upon the Principle of Excluded Middle, just as the judgments we have previously considered are expressions of the Principle of Identity.

In the perfect disjunctive judgment a system is completely and accurately expressed. In such a case the alternative predicates between them exhaust the whole system, and each is exclusive of all the others. The judgment imposes a necessity to choose in any particular instance amongst those alternatives, and in this necessity is found the basis for the sufficiency of the condition stated by the hypothetical judgment. For in a system perfectly expressed by the judgment "S is either P or Q" it is evident that "If S is not P it is Q," and "If S is P

it is not Q"; and these involve "If S is not Q it is P," and "If S is Q it is not P." The disjunctive, therefore, implies the hypothetical. But it has also a categorical aspect. For though no particular fact S can be indifferently P or Q, but must be one or the other and that alone, yet P and Q are always themselves only divisions of a wider predicate which embraces them both, and whose scope they together exhaust. This wider predicate is fixed by the topic of thought in connexion with which the judgment is made. If, for example, P, Q . . . Z are colours, then the wider predicate is "colour," and of this P, Q . . . Z are differences. The attribution of this wider predicate to the subject shows the general nature of the system of reality which the disjunctive judgment expresses.

Knowledge of system is, however, in many cases imperfect, and many judgments expressed in the disjunctive form do not fulfil all the conditions just laid down, just as many generic and hypothetical judgments fall short of the ideal of exact thought in that they are not reciprocal. The imperfections of the disjunctive judgment are either that the alternative predicates do not exhaust the whole realm of possibility, or that they do not exclude each other. In the former case we have not a real disjunctive judgment at all, but only a vague and indeterminate categorical judgment; for the very essence of disjunction is that from the denial of one alternative we can pass to the affirmation of the rest, so that by the successive denial of every alternative but one we can pass with certainty to the knowledge of the reality of that one. The latter case also indicates a defective knowledge of system, and, indeed, shows that in actual life the disjunctive form is used to express doubt as well as organized

knowledge. Our first example would justify the concrete judgment "All graduates of London have taken a degree in either arts, science, law, medicine, or music," and we know that any one person may have graduated in more than one faculty, and from that point of view we might affirm that the alternative predicates in this judgment are not exclusive of each other. But the logical subject of the judgment is not graduates, but the constitution of the university so far as relates to the conferring of degrees. Thus regarded, it is seen at once that graduation in any one faculty is, as a particular act, exclusive of graduation in every other faculty. If an individual graduates in a plurality of faculties it must be on a plurality of occasions, each of which excludes the other. So it is in every true disjunctive judgment. In so far as the alternative predicates differ they exclude each other. But, as is seen in the above example, this exclusion may not apply to their relation to the grammatical subject, unless that is also the true logical subject. We must not, therefore, assume such exclusion from the mere form of the proposition. In other words, we must not regard any given disjunctive proposition as involving the hypotheticals "If S is P it is not Q," and "If S is Q it is not P," unless we have evidence that P and Q cannot coexist in any one instance of S.

§ 3.—So far, we have limited the discussion to cases in which our universal assertions would stand the test of experience. We know, however, that this is not always the case. We meet with exceptions to many statements which were at first thought to be general. Hence arise both negation and limitation of the scope of our judgments. We have all the force of negation whenever two judgments are made of the same subject which cannot

Negation.

both be true, because their predicates are incompatible with each other, as when "on a particular occasion during a . . . visit of the Empress of Germany to London, it became the duty of the reporters of the public journals to describe Her Imperial Majesty's dress. Subsequently the *Globe* collected the descriptions of the costume as they were given by different reporters, to this effect: The *Times* stated that the Empress was in 'gold brocade,' while, according to the *Daily News*, she wore a 'sumptuous white silk dress.' The *Standard*, however, took another view: 'The Empress wore something which we trust it is not vulgar to call light mauve.' On the other hand, the *Daily Chronicle* was hardly in accord with any of the others: 'To us it seemed almost a sea-green, and yet there was now a cream and now an ivory sheen to it.' No wonder that the *Globe* asks emphatically, 'What *did* the Empress wear?' " ¹ Each of the judgments here quoted really negates all the others, because only one of them can possibly be true. No negation, however, appears on the face of any of these judgments. We get such explicit negation when the judgment takes the negative form, "S is not P."

A consideration confined to this bare form would, however, lead us to a very wrong conception of the nature of negation and of its work in thought. For in form the negative judgment is bare denial, and the P is not limited to any system of predicates. The form would cover such a statement as "Virtue is not green," quite as well as "The dress of the Empress is not green." But it is obvious that of these two only the latter has any rational meaning. The former does not correspond to an act of thought at all; in other words, it does not represent a real

¹ Rooper, *School and Home Life*, pp. 83-84.

judgment. As we have seen, every judgment is made under a certain limitation of reference which is made clear by the context in which it actually occurs. This is the same as saying that every judgment is made within a certain system. If the predicate is "green," the system is that of colour, and only things occupying space can be coloured, for they only are visible. Consequently we can only rationally deny any particular colour of things which occupy space.

Further, it has been shown that in this limitation to system is found the justification for our judgments, and that no judgment can be made without a ground. Denial must, therefore, rest upon some ground. But bare denial only expresses ignorance, and knowledge cannot be constructed out of ignorance. Denial always rests, then, on a positive ground, and this ground is the presence of something in the reality with which the judgment deals which is incompatible with the proposed predicate. We can rationally assert that S is not P only when we know more or less definitely that S is Q , and that Q cannot co-exist with P in the same subject. Our apprehension of Q may, indeed, be by no means explicit; we may only feel sure that if S were to receive P it would cease to be itself, but we cannot feel this unless we believe there is something in S which excludes P , and this something is the Q of our symbolic statement.

It appears, then, that every negation rests upon an implicit disjunctive judgment, and as a consequence that denial and affirmation mutually imply each other. Every denial is based on an affirmation, and every affirmation negates all the other alternative and incompatible predicates in the system to which the judgment is limited. The use of the affirmative or the negative form shows which aspect is predominant

in thought, and this is determined in general by the purpose with which the judgment is made.

Quality and
Quantity in
Categorical
Judgments.

§ 4.—These considerations have also made plain that the true function of negation in the work of constructing knowledge is to show the limitations within which our affirmations should be confined.

Suppose that in opposition to the universal categorical proposition "Every S is P," an exception is proved to exist. We have then to grant that "this S at any rate is not P." But the original judgment was based upon the generic judgment "S as such is P," which had been supposed to be true. We must now, therefore, grant that "S need not be P." But if the original judgment rested on any real evidence at all, it has not been entirely disproved, but only limited in its scope. We can still say "S may be P," or with more direct reference to particular facts, "Some S's are P." The distinguishing feature of such a judgment is the indefiniteness of the reference to S. Similar forms arise from unanalysed experience. We have seen that mere uniformity of occurrence will not justify us in making the universal judgment "Every S is P," but it will justify us in making the *particular* judgment "Some S's are P." And when we do so, we use the word 'some' without prejudice to the possibility that 'every' would be true in fact. 'Some' means in such a case that our knowledge is professedly imperfect; we know there are cases—one at least—in which S is P, but our knowledge of the nature of the reality thus expressed is insufficient to enable us to say whether *every* S is P. In other cases in which we use the word 'some,' we do intend to exclude 'all,' but this can only be assumed to be the case when the context makes it perfectly clear. For example, suppose on examining the tabulated results of an examination we found that certain candidates

had failed in mathematics. We could immediately affirm that 'some' candidates had so distinguished themselves. But it is conceivable that further examination of the results might show that this 'some' could with truth be expanded into 'all.' This discovery would not make the former judgment false, but only turn it from an indefinite into a definite assertion.

So long, then, as we have nothing but the form to guide us, that is, whenever we have no context of knowledge to show that the 'some' is meant to exclude 'all', we must assume that 'some' means "I am sure of at least one case, but I do not know how widely my judgment will apply." Even when the context shows that 'some' is known not to be 'all' as when we say "Some boys are idle and some are industrious," yet the range of application of these particular judgments is always indefinite. They cannot, therefore, be a resting place for thought in its search after knowledge. By their very form they challenge further enquiry. But as the universal judgment can only be reached by such an analysis of content as will lead to the generic or the hypothetical judgment, so the line our investigations must take to transmute the particular into the universal judgment is further and more accurate analysis of reality. This may result in the finding a condition M which necessitates P, and then we have the hypothetical "If S is M it is P," or the generic "S which is M is P," which are alternative ways of expressing the same judgment.

It is, indeed, in some such process of finding exceptions to judgments supposed to be universal, and in the consequently more exact determination of those judgments through further search into reality, that advance in knowledge generally consists.

The foregoing discussion has brought out that the chief formal distinctions in categorical propositions

are those of *Quality*, between affirmative and negative, and of *Quantity*, between universal and particular. The latter distinction is determined by whether the proposition refers explicitly to all the individuals which bear the subject name, or whether its application is indefinite.

Quality and
Quantity in
Hypothetical
and
Disjunctive
Judgments.

§ 5.—If we now ask whether the same distinctions can be applied to hypothetical and disjunctive judgments we find that this is only very partially the case. The negative form is perfectly appropriate to the hypothetical judgment, for a condition M may be found united with S, which is incompatible with P, and this is appropriately expressed by the form "If S is M it is not P." It is also possible to write particular judgments in a hypothetical form, and say "If S is M it may be P," and "If S is M it need not be P." But this does not make the judgments really hypothetical, and is, therefore, misleading. Every particular judgment directly asserts fact, and for this the categorical is the appropriate form; whilst the special function of the hypothetical is to express necessary connexion of a result with its conditions. As such a connexion must be universal, the hypothetical form should only be used for universal judgments.

Similarly, as the function of the disjunctive form is to express known relations within a system, it is evident that a statement of the form "S may be P or Q" has little of the essence of disjunction in it: it is mainly an expression of ignorance, and the underlying judgment is categorical. Further, it is impossible to have a negative disjunctive judgment. If we would deny the disjunctive "S is P or Q" we must say "S is neither P nor Q," but this is not disjunctive but categorical. In short, the denial of a system does not involve the affirmation of an opposed system.

CHAPTER VII

FORMAL RELATIONS OF PROPOSITIONS

§ 1.—We saw in the last chapter that the chief formal distinctions of judgments are those of quality and quantity. It was by considering these, and ignoring the content of judgments, that the four-fold scheme of categorical propositions, which has been traditional in logic since Aristotle, was produced. For it is evident that a proposition must by its very form either definitely refer to the whole range of reality indicated by the subject or leave the scope of its application doubtful. The former case is expressed in the affirmative by “Every S is P” or “All S’s are P,” the latter by “Some S’s are P;” in the negative the former by “No S is P,” and the latter by “Some S’s are not P.”

The Four-fold Scheme of Propositions.

It should be noted that the form “Every S is not P” is not adapted to express the universal negative, because it is ambiguous. It may intend to deny P of every S which exists, when it is universal in its force; or it may only intend to deny that we can affirm P of every S, and this would be true if P can be denied of a single S; it is then particular. For instance if we affirm that “All that glitters is not

gold," we do not mean that no glittering things are gold, but only that some glittering things are not gold. The proposition is, therefore, particular.

It is possible to express more or less adequately every categorical judgment in one or other of these four forms, if we include the impersonal and demonstrative judgments under the particular; and the judgments of particular relation and historical singular judgments under the universal, on the ground that they definitely refer to the whole of their subjects. In doing so, however, we ignore the important distinction between such singular judgments and the true universals. Moreover, the form "Every S is P" is used indifferently for the mere results of counting, as "All the boys are tired," and the judgment of necessary connexion, such as "All equilateral triangles are equiangular." However, certain relations hold between these forms of proposition which we shall do well to examine briefly.

The four forms of proposition are traditionally indicated by the letters **A, I, E, O**, which are the first two vowels in the Latin word *affirmo*, I affirm, and the vowels in *nego*, I deny. The symbols are thus distributed—

- A**.....Universal Affirmative...Every S is P.
I.....Particular ,, ...Some S's are P.
E.....Universal Negative.....No S is P.
O.....Particular ,, Some S's are not P.

Distribu-
tion of
Terms.

§ 2.—We saw in chapter iii that every term has a meaning or content, and a denotation, or range of objects to which it is applicable. Both these aspects are always present in categorical judgments, but the denotation is the more prominent in the subject and the meaning or content in the predicate. As, however, every term always has a reference to reality, it is

permissible to consider the denotation of the predicate as well as that of the subject. A term is technically said to be *distributed* when definite reference is made to the whole of its denotation. Thus the subjects of the **A** and **E** forms of proposition are distributed. When the predicates are examined, it is seen that those of the affirmative propositions are undistributed, for the assertion that P belongs to every S, or to some S's, evidently makes no definite reference to the whole extent of the application of P; other things besides the S's referred to in the proposition may be P. When we turn to the negative forms, however, we see that P is, in each case, distributed; for whether it is every S or only some S's which are to be excluded from P, yet that exclusion is only made when they are shut out from every possible case of P, and P must therefore be explicitly referred to in its whole denotation. Summing up these results, we see that—

E	distributes both its terms.
A	„ its subject only.
O	„ its predicate only.
I	„ neither term.

§ 3.—Dependent on this is what is called *Con-* Conversion.
version, that is, the transposition of subject and predicate in a proposition. In this process no undistributed term may be made distributed, for that would evidently be going beyond the assertion of the original proposition.

It follows that **E** and **I** propositions can be converted *simply*; that is, into propositions of the same form, as both the terms in each of these propositions are the same in distribution. Whether we say “No S is P” or “No P is S”; “Some S's are P” or “Some P's are S,” in each of the two cases we are

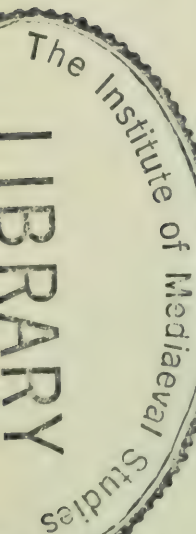
expressing exactly the same idea, and the form in which we put it is a matter of no logical interest.

It is also plain that an **O** proposition cannot be converted at all, for to pass from "Some S's are not P" to "Some P's are not S" would be to distribute S, and therefore to pass beyond the "Some S's" with which we start.

If we now examine the **A** form of proposition, we see that it can only be converted to the **I** form, as the P is given us undistributed. This is appropriately termed *conversion by limitation*. In this process, therefore, we pass from a more definite to a less definite assertion, for we lose sight of the distribution of S. From "All cats are animals" we reach by conversion "Some animals are cats" which is only equivalent to "Some cats are animals." We have passed from expressing knowledge to expressing partial ignorance. As Dr. Bosanquet says, "We seem . . . only to have advanced to a doubt of what we knew."¹ It is true that if we look at meaning there is a difference of emphasis in passing from, say, "All sponges are animals" to "Some animals are sponges." But this is of psychological rather than of logical interest; the judgment underlying both propositions is one single act of thought, and remains unchanged; hence the new expression is inadequate.

To call these processes of conversion, inference, is only justifiable if every change of form is held to indicate a change of thought, and this is certainly not the case. "The transposition is . . . of rhetorical rather than logical value. 'Who deniges of it, Betsy?' inquired Mrs. Gamp; and then Mrs. Gamp, by reversing the order of the question, imparted a more awful solemnity to it, 'Betsy, who deniges of it?' This is the philosophy of all conversions and all

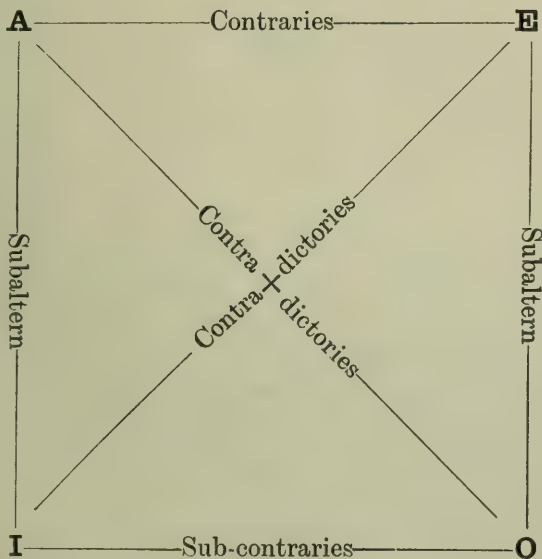
¹ *Logic*, vol. i, p. 327.



substitutions of one verbal equivalent for another, in a nutshell."¹

§ 4.—We have now to enquire how the truth or falsity of a proposition in any one of these four forms which deal with the same matter, that is, have the same subject and predicate. It has been traditional to call these relations of truth and falsity "the opposition of propositions," where the word "opposition" merely means comparison of differences of form, whether those differences imply real opposition, *i.e.*, incompatibility in meaning, or not. The relations have been for many centuries indicated in the following diagram, which is called "The Square of Opposition."

Modes of
Opposition.



Examining the propositions in pairs as indicated by the diagram we take first the *Subaltern* relation, a name derived from the diagram. **I** and **O** are

Subalternation.

¹ Hobhouse, *The Theory of Knowledge*, pp. 259—260.

called "subalterns" to **A** and **E** respectively, because they are written under those letters in the diagram. We see at once that the assertion of a universal obviously includes the assertion of its subaltern, *i.e.*, the particular of the same quality. Thus, to assert **A** is to assert **I**; to assert **E** is to assert **O**. But this will not hold in the case of denial. The fact that the hasty psalmist was unjustified in affirming that "All men are liars" by no means proves that the more modest assertion "Some men are liars" would not be true. On the other hand this latter proposition will not justify the former: we cannot affirm the universal on the basis of the particular. But if we deny the indefinite particular, our denial evidently applies yet more strongly to its corresponding universal.

Contradiction.

When we take propositions of opposite quality we see that **A** and **O**, **E** and **I**, respectively, are pairs of *Contradictories*. The essence of contradiction is that of two contradictory propositions one must always be true and the other false. Thus to assert **A** is implicitly to deny **O**, to deny **A** is implicitly to assert **O**; whilst these relations also hold the other way, that is, to deny **O** is to assert **A**, and to assert **O** is to deny **A**. Similar relations hold between **E** and **I**. This all follows directly from the Principles of Contradiction and Excluded Middle.

Contrariety.

If the propositions considered are **A** and **E** then it is obvious that both cannot be true, but both may be false. That "No men are liars" would be as rash a statement as that "All men are liars." These propositions are called *Contraries* because the assertions made by them are the furthest removed from each other which it is possible to make about any one subject matter.

Lastly, when we consider the two particular forms

of proposition, **I** and **O**, we see that they are formally indifferent to each other: both may be true together, and this is always the case when the 'some' is in fact limited to part of the denotation of **S**: that "Some men are liars" and that "Some men are not liars" are equally true. It is evident, however, that both these propositions cannot be false if there exist any **S**'s at all; this directly follows from the Principle of Excluded Middle. These propositions are technically called *Sub-contraries*, simply because of their position in the diagram of the Square of Opposition.

Sub-contrariety.

If we now collect our results we see that when **A** is true, the truth of **I** and the falsity of both **E** and **O** are implied; but when **A** is false the only implication is the truth of **O**. Corresponding results hold with **E**.

Summary of
Opposition.

Again, when **O** is false, the falsity of **E** and the truth of **A** and **I** are implied; but when **O** is true, nothing is implied but the falsity of **A**. Similar implications are involved in the truth or falsity of **I**.

To put it generally: the truth of a universal, or the falsity of a particular carries with it implications as to the truth or falsity of each of the other members of the four-fold scheme; but the falsity of a universal or the truth of a particular only implies the truth or falsity respectively of its contradictory.

CHAPTER VIII

THE METHOD OF KNOWLEDGE

Truth and
Evidence.

§ 1.—In chapters v and vi we considered what is implied by the act of judgment at its various stages of development, and so found an answer to the fundamental question as to the meaning or content of judgment. There remain for examination the two much more difficult enquiries relating to truth and evidence, and these will occupy us throughout the remainder of the book. These two questions cannot well be separated. No one ever accepts as true a statement which does not rest on evidence which he deems sufficient. But evidence which appears conclusive to one mind is often rejected by another as insufficient or even as altogether worthless. Our task, then, is to consider what is the final test of truth, to examine the kind of evidence on which judgments which satisfy that test are grounded, and to ascertain how such evidence is procured. In brief, we have to seek an answer to the question: By what method does man attain knowledge?

Nature of
Method.

§ 2.—*Method* implies orderly procedure, that is, procedure guided by some definite principle. It is only when a task is pursued methodically that it is

well done, and the more difficult the task the greater is the need of method. To nothing does this apply so forcibly as to that most difficult of all tasks—the acquisition of knowledge. Without method a desultory collection of pieces of information may be picked up, but nothing that deserves the name of knowledge can be attained. The nearer the method in any science approaches perfection, the greater are the advances made in that branch of knowledge. This has always been recognized by thinkers, and it may be said that all systems of logic have been simply attempts to formulate the essential features of the methods by which knowledge has been sought at various times. Thus the logic current at any time is relative to the test of truth or knowledge accepted at that time.

Logic, as an organized body of doctrine, originated with the attempt of Aristotle to systematize the methods by which men's thoughts and beliefs could be brought into harmony with each other, and so fulfil the test of truth accepted by Greek thinkers.

Develop-
ment of
Doctrine of
Method—
Aristotle.

In the Middle Ages this test of truth was exchanged for mere agreement with dogmas. Certain general propositions were accepted as self-evident, and the whole work of thought was to deduce the consequences of these principles. The mediæval logic was an attempt to set forth in detail all the conditions under which such deductions could be made. It was extremely acute, but was naturally concerned with the bare form of thought, for truth was held to consist merely in agreement with certain original propositions whose truth was unquestionably accepted. This logic was derived from that of Aristotle, but practically omitted all those parts of Aristotle's work which dealt with the establishment of true universal propositions. Another con-

*Mediæval
Logic.*

sequence of the mediæval view of knowledge was a false conception of the function of logic. It was held that the province of logic was to legislate for thought; to lay down the methods by which alone truth could be attained.

Bacon. With the development of natural and physical science which began in the sixteenth century the mediæval test of truth was gradually discarded, and the view arose that the only test of truth is agreement with fact. Such agreement could be neither proved nor disproved by the mediæval logic, and so the need for a new formulation of the method of knowledge was felt. This task was avowedly undertaken by Francis Bacon. Unfortunately, however, he retained the mediæval view that the function of logic is to lay down with authority the methods which scientific investigation must follow. He himself had not studied the methods by which Copernicus, Galileo, and the other great pioneers of science, really worked. He believed that an enormous collection of facts, followed by careful comparison and classification, would make the hidden truths of nature immediately obvious. The method was fundamentally a mistaken one, and, as Jevons says, "it has not been followed by any of the great masters of science."¹ But it had the merit of drawing attention to the need of verifying theories by appeal to fact. "Against this . . . must be set the fact that by calling his method induction, and laying so much stress on the collection of facts, he fostered, and, indeed, fixed in the public mind the erroneous idea that the whole work of science consists in observation."² This idea really makes method mechanical; for it conceives method as an artificial arrangement in

¹ *Principles of Science*, p. 507.

² Minto, *Logic, Inductive and Deductive*, p. 253.

a body of knowledge which is external to the mind and independent of its activity. This was indeed plainly claimed by Bacon himself: "Our method . . . of discovering the sciences is one which leaves not much to acumen and strength of wit, but nearly levels all wits and intellects."¹

Bacon's idea of method, as we have said, had little influence on the actual work of scientific discoverers, and it is not to him but to Newton that modern science owes the first clear formulation of its general method. *Newton.*

Logicians, however, long ignored the revolution which was being effected in the method of knowledge, and continued to expound the old mediæval logic, with all its claims to set forth the "art of thinking." This led naturally to logic itself falling into very general contempt; its system was seen to be largely artificial, and out of relation to the modes of thought actually proved successful in every branch of science. To Mill belongs the credit of rescuing logic from death by inanition. He grasped the truth that the function of logic is not to dictate method to science, but to accept the methods which science finds successful in the ascertainment of truth, and by analysis to make clear their essential general features. Then, he hoped, the same methods which had led to such advances in the natural and physical sciences, might be found equally fruitful in those sciences which deal with the mental and moral life of humanity, such as history, sociology, ethics, and psychology. This view of logic has become the accepted one; logic no longer claims to be the lawgiver to the sciences, but owns itself dependent upon them in its formulation of method. *Mill.*

¹ *Novum Organum*, I, 61.

*Modern
Logic.*

Since Mill's great work, the development of logic has been chiefly in deepening and making more exact the conception of knowledge. It is seen that agreement with fact is not a sufficient test of truth, if 'fact' is restricted to mean something observed by the senses. Science more and more finds truth in universal relations and laws, of which particular facts are but manifestations and examples. Our test of truth is that ultimate consistency and relation of universal judgments, verified by appeal to facts, which we mean by system. Thus the modern view is in one sense a return to that of Aristotle, but a return which lays emphasis also on that need of agreement with fact on which modern science rightly insists.

*Method and
Thought.*

§ 4.—This criterion of truth implies that method is essentially an order of thought, and not an order of things. It is that process of self-activity in which the mind of man satisfies its own rational nature by finding reason as the guiding principle of the universe. It is not a process by which an order of external nature is stamped on a passively receptive mind. As Coleridge put it, "Method implies a progressive transition, and it is the meaning of the word in the original language. . . . The term, method, cannot, therefore, otherwise than by abuse, be applied to a mere dead arrangement, containing in itself no principle of progression."¹ It is the presence of such a principle of progression—of gradual development from incompleteness and imperfection towards completeness and perfection of knowledge—which marks every true science. For a science is the result of mental activity bringing itself into harmony with world activity; its success is marked by agreement with fact on the one hand, and by a growing appre-

¹ *The Friend*, vol. iii, p. 116.

ciation of the ultimately rational character of the grounds of knowledge on the other.

§ 5.—Important, therefore, as it is to remember that knowledge is mental construction, it is equally essential to bear in mind that it is construction based on sense experience, and subject throughout to the test of such experience. A method of knowledge must, therefore, analyse the ways in which this experience can be made explicit; in other words, enquire how an exact and definite knowledge of facts can be obtained. Now all human knowledge of material facts is derived in the last resort from direct observation. We shall have, then, to consider how we can guard against errors due to faulty or careless observation, so that our fabric of knowledge may be based on a sure foundation. In a word we shall have to enquire how it is possible to obey the maxim "Make sure of your facts."

Method and
Facts.

But though in the last resort all knowledge of facts rests on direct observation, yet that last resort is unattainable for every one of us in an indefinitely large number of cases. Every searcher after knowledge has to accept much on the testimony of others. "In the best scientific work, even as in the worst, much must be taken upon trust; on the authority of the competent observer, skilled instrument maker, or original investigator."¹ A method of knowledge must, therefore, indicate what tests of truth can be applied to testimony, so that only the trustworthy may be accepted. No formulation of method can be satisfactory which drops out of sight "the complex interchange of opinion, observations, experimental results, criticisms—the division of labour—that constitutes the life of science."²

¹ Ravenshear, *Article on Testimony and Authority, Mind*, N. S., vol. vii, p. 63.

² *Ibid*, p. 64.

Inferential
Character
of Method.

§ 6.—The ascertainment of facts is, however, only the starting-point of knowledge. The very aim of every science is to extend knowledge beyond mere facts to those universal relations which can be found in those facts by the operations of thought, and to reason from those laws to their consequences, thus reaching knowledge of other facts which have not been observed, and binding the whole into one comprehensive system of knowledge. All such operations of thought are included under the general name of *Inference*. The aim of inference and the final step of method is thus seen to be the construction of system and the finding in system that explanation which is the ultimate goal of thought.

Our examination of Method will, therefore, fall under three main heads:—Observation and Testimony; Inference; System and Explanation. But these must not be regarded as three stages of progress separated in time. They are inseparable in the actual development and construction of knowledge, though for convenience and clearness we can consider them apart.

We have seen that system is simply the completion of inference, and it is obvious that the testing of the trustworthiness of testimony must also be a process of inference. It is not so evident at first sight that observation also implies inference, but further consideration shows that it is so. This will be worked out in our discussion of observation.¹ It is sufficient here to point out that wherever error is possible we shall do well to suspect the presence of inference. The impression on the senses is what it is, but even in the simplest cases it may appear to us to be something else, and so the judgment which expresses what the sense-impression is to us—i.e., what *observation*

¹ See Chapter xi.

we have actually made—may be false.¹ Now, the grounds of this falsity cannot be found in the mere sense-impression, for that asserts nothing. It must, therefore, be sought in the act of mental construction by which we bring that impression under a certain idea. And such construction is of the nature of inference, for it asserts the character of an impression on the grounds of its resemblance to impressions not now experienced. For example, the rustic who takes a gravestone brightened by the moon for a ghost, infers the ghost from the similarity of the sense-impression he actually receives with the brightness and whiteness which form the essential features of his idea of the appearance of ghosts, his inference being supported by the fact that the midnight hour is the orthodox time for ghostly manifestations.

It appears, then, that the method of knowledge is inference throughout, and it will be necessary to consider the nature of inference before entering on an examination of the precautions which should be taken to secure that observation is expressed in true judgments of fact.

§ 7.—Before taking up this enquiry, however, it will be well to consider more definitely what is implied in speaking of any process of thought as methodical.

Character-
istics of
Methodical
Thought.

Such a process may combine an indefinite number of inferences ; it may be of any length and of any degree of complexity. But whatever its length or complexity, it is methodical just in so far as it is dominated by a purpose. All methodical thought, as we have seen, leads to system, and the idea of system is implicit in it from the first. Of course, in the beginning of an enquiry we have no system ready made. The actual concrete system which our

Purpose.

¹ Cf. pp. 22, 92.

enquiry aims at reaching is learned from the facts themselves.

*Definite
Starting-
point.*

Observation of facts, then, suggests the kind of problems whose solution will constitute the system in which they have their place. So "in every science the next step after observing the facts is to formulate a series of questions according to some methodical system ; every science is composed of the answers to such a series of questions."¹ Often, indeed, an answer is suggested together with the question, and then this has to be tested. The process of finding or of testing the answers to the questions thus suggested will generally involve much more observation of facts, and this again will suggest other problems, and so one enquiry grows out of another. But unless the original observations are accurately made, the whole enquiry is likely to prove futile. Or again, if in any enquiry we start from a general proposition whose truth we assume, and that proposition is in reality wholly or partially false, then our labour is vain.

These considerations yield us two closely related and fundamental rules of method—

1. *Have a definite purpose.*
2. *Make sure of your starting-point.*

Fallacies
Incidental
to Method.

§ 8.—Neglect of one or both of these leads to *Fallacy*, that is, to invalid thought disguised as valid thought. This is most likely to occur in exposition or in argument.

*Petitio
Principii.*

If the purpose is confused with the starting-point, we have the fallacy of *Begging the Question*, or, in its technical Latin name, *Petitio Principii*. This means the assumption, as the basis of proof, of the very proposition we set out to prove, or of a proposi-

¹ Langlois and Seignobos, *Introduction to the Study of History*, Eng. trans. by Berry, p. 214.

tion implying it. The possibility of expressing the same judgment in various forms of words renders it easy for such fallacious arguments to pass current. The fallacy is committed, for instance, when we are told that "opium produces sleep because it has a soporific quality," or that "the volume of a body diminishes when it is cooled, because the molecules then become closer."

Perhaps the most common mode of committing this fallacy is the acceptance of sham axioms, generally received from tradition, and the use of them as bases for inference. Of these many thousands have been received amongst men, and many are still held with unquestioning faith. We will quote a few: That nature abhors a vacuum; That other metals can be transmuted into gold; That all men are equal; That slavery is natural; That all children are born wholly good; That all children are born wholly inclined to evil; That in all trading the gain of the one party is the loss of the other; That dreams are prophetic; That like cures like.

An excellent example of this form of the fallacy is to be found in the First Chapter of Mr. Herbert Spencer's *Education*. After stating that "acquirement of every kind has two values—value as *knowledge* and value as *discipline*," the author discusses the value of most subjects from the point of view of knowledge. He then turns to disciplinary value and begins his remarks with the following *petitio*:—"Having found what is best for the one end, we have by implication found what is best for the other. We may be quite sure that the acquirement of those classes of facts which are most useful for regulating conduct, involves a mental exercise best fitted for strengthening the faculties. It would be utterly contrary to the beautiful economy of Nature, if one kind of culture were

needed for the gaining of information and another kind were needed as a mental gymnastic.”¹

*Ignoratio
Elenchi.*

A vague conception of the purpose often leads to the fallacy of *Arguing besides the mark*—*Ignoratio Elenchi* as it is technically termed. To meet a man's arguments by a charge of inconsistency, or by personal abuse, is to furnish a case in point. “To knock a man down when he differs from you in opinion may prove your strength, but hardly your logic.”²

Another mode of committing the fallacy is to appeal to prejudice or to sentiment. The following “argument” against the study of literature is a striking instance: “When a mother is mourning over a first-born that has sunk under the sequelæ of scarlet-fever—when perhaps a candid medical man has confirmed her suspicion that her child would have recovered had not its system been enfeebled by over-study—when she is prostrate under the pangs of combined grief and remorse; it is but small consolation that she can read Dante in the original.”³

The fallacy may also be committed by ignoring the arguments by which your opponent supports his conclusion, and setting up in their place a “man of straw” which you then triumphantly demolish. A good instance is furnished by the objection to a classical education that “throughout his after career, a boy, in nine cases out of ten, applies his Latin and Greek to no practical purposes.”⁴ Or again: “As the Orinoco Indian puts on paint before leaving his hut, not with a view to any direct benefit, but because he would be ashamed to be seen without it; so, a boy's drilling in Latin and Greek is insisted on, not because of their intrinsic value, but that he may not be disgraced by being found ignorant of them—

¹ *Education*, p. 41.

² Stock, *Deductive Logic*, p. 313.

³ Spencer, *Education*, p. 28.

⁴ *Ibid*, p. 2.

that he may have 'the education of a gentleman'—the badge marking a certain social position, and bringing a consequent respect."¹ Of course Mr. Spencer has no difficulty in showing that these are not valid grounds on which to select a curriculum. But such showing is the veriest beating of the air so far as the arguments based on the disciplinary value of classical studies are concerned. And it is on these that the advocates of such studies mainly rely.

In using illustrations, we need to be continually on our guard against this fallacy. An illustration is intended to make clear something which the learner finds obscure. But the teacher may mistake the difficulty, and so direct the illustration to the wrong point. The same error may be made by the learner. For, as De Morgan well says, "the greatest difficulty in the way of learners is not knowing exactly in what their difficulty consists; and they are apt to think that when *something* is made clear, it must be *the something*."² Especially is this the case when an abstract relation is illustrated by concrete examples. There is always the danger that it is *something* in the particular examples really irrelevant to the point under consideration which has been understood, and generally "the minds which are best satisfied by material instances are also those which give themselves no further trouble."³

Another form of this fallacy to which the use of illustrations is liable is that the learner may fail to see the analogy between the illustration and the difficulty it is meant to make clear. Such considerations show that great care is needed to make sure that an illustration really fulfils its intended function.

¹ Spencer, *Education*, p. 2.

² *Formal Logic*, p. 266.

³ *Ibid*, p. 267.

Essence of
Methodical
Process.

§ 9.—Methodical process must, then, have a definite starting-point and a definite purpose. But it is in the continuous transition from the former to the latter, that method is found. We cannot have orderly procedure unless we first know whence we are starting and whither we wish to go. But it is quite possible to know these and yet to wander by the way. How such wandering may be avoided in any particular case must be determined by the special science concerned. Our task is only to find by the analysis of successful procedure, what are the general characteristics of such method. These characteristics may be summed up by saying that *methodical process omits nothing, takes up the points one by one, and takes them up in such an order that it goes from the starting-point to the fulfilment of the purpose by consecutive steps, each of which is seen in its true relation to every other step and to the enquiry as a whole.*

Nature of
Inference.

§ 10.—It is evident that in the process of discovery nothing more than an approximation to this ideal can be expected, just because the system is in the process of making. It is only when the process is complete and has become proof that all which really lies outside the direct path can be swept away, and the passage of thought from starting-point to goal be seen as a necessary and continuous transition. Such perfect examples are, for instance, found in many of Euclid's proofs of geometrical truths. A process of inference is, then, logically perfect when it has ceased to be discovery and has become proof. Whether the process is familiar or new to any individual mind has nothing to do with its logical character. It is, therefore, a mistake to confine the term 'inference' to cases in which an individual reaches a truth hitherto unknown to him. The essence of inference is that

thought passes continuously from starting-point to conclusion in a path necessitated by the character of the system. The conclusion is 'new,' not in the sense of being unfamiliar to any particular person, but in the sense of not being apparent in the premises—or judgments from which the process starts—though it is a necessary consequence of their combination. The inference is the whole construction, not the mere passage of thought between beginning and end.

The question of inference then is this: Given certain truths, how can we reach other truths which go beyond those which are given? The answer must be sought in the conception of system with which inference is indissolubly connected. Whenever we can put a given fact or a given judgment into a system, we are able to make it the starting-point of inference. For instance, suppose we have a small bud from a rose-tree. What is apparent to observation is just a little green hard object about the size of a pea. If we pull it to pieces we can observe more, but we cannot observe in that rose-bud the full flower which would, under favourable conditions, have developed from it if it had been left on the tree. But when we see a rose-bud we are able, not simply to think about the rose-bud as it is now, but to carry our thoughts on to the full-blown rose. This is possible because we have sufficient knowledge of the matter to know that bud and flower are parts of the one system of the life of the rose-tree, so related that flower is the natural outcome of bud. We are then able to construct that system in our minds, and from that construction to derive the judgment that the flower should follow the bud. Evidently the definiteness of our conclusion is dependent

Inference
and System.

upon the extent of our knowledge of rose-tree life. One person may be able to state only the general fact of sequence, another will give more or less approximately the time the transition will occupy. The more exact the mental construction, the more exact is the conclusion which that construction makes apparent.

We borrow the next example: "My train is half an hour late. I know I must miss my connexions at the station ahead; for the train I am hoping to catch at that place is scheduled to leave five minutes after the time of arrival of the train I am now on. The time relations here necessitate my missing my connexions. This is rendered still more certain if they are rival roads; on no account will one wait for the other. Moreover, the train I hope to make is made up and leaves the station in question, and so I cannot fall back upon the favouring chance that it also may be detained en route, and so enable me, after all, to reach it in time. Thus, with every additional knowledge of the system which forms the ground of my inference, and the various conditions which affect it, the validity of my inference is thereby increased."¹

Inference is, then, mental construction based on knowledge of particular systems and of such a character that a result not explicitly given in the premises can be immediately apprehended by thought when the construction is made. It is obvious from this that our power of inference is in every case essentially relative to the amount of our knowledge of the appropriate system. For example, a little child or a savage sees a heap of gunpowder for the first time, so that to him it is merely a heap of something like black sand. The civilized adult who

¹ Hibben, *Inductive Logic*, p. 10.

recognizes it as gunpowder puts it into a different system, which embraces and goes beyond that of the child. From this system he can infer the effects of the application of a lighted match—a result which the child or savage could only discover by an experiment which might be disastrous. But the gunpowder is the same, whether observed by child or gunner or chemist; the difference is in the system of knowledge possessed by the observer. It is this which makes inference possible, though it is not itself inference.

When we know a system we can pass from fact to fact within it. But the path from fact to fact is always through a universal relation, that is, through some identical quality common to both the facts. All increase of knowledge is the finding such universals. The more universal ideas we can think a thing under, the more we know about it, and every such idea is a relation. Inference cannot stir without universals, but it must be remembered that the universals are in the facts, only needing to be found there by thought, though they cannot be discerned by the senses.

Inference
and Uni-
versals.

Inference, then, is the working out of system—the thinking facts under universal relations, and the finding universal relations exemplified in facts. A mere fact which cannot be brought into any system is meaningless to us; and the greater the number of systems a fact can be placed in the more it means to us. Incidentally it may be pointed out here that the aim of teaching is not to impart facts but to develop systems; facts are only of value in so far as they are starting-points for such development.

§ 11.—Inference, or the making explicit the contents of a system, is a process which may begin from either of two starting-points. We may know some universal relation which covers the whole system,

Deductive
and In-
ductive
Inference.

and from that proceed to develop by inference the particular contents of that system. This method of inference is called *Deductive*. It starts with the universal and applies that universal to the particulars which express it. It is, therefore, predominantly a synthetic process, as its function is to bind together particulars in a known system.

On the other hand we may have only a number of given facts, and our task is then to find a system which will exhibit all these facts in consistent relations to each other and to the rest of human knowledge. This is called *Inductive Inference*. It starts with particulars and tries to find the universal they embody. Thus it is primarily an analytic process, as it can only find the universal it seeks by analysing the given facts. This makes it more or less tentative, as every particular fact embodies many universals, and more than one solution of an inductive problem is, therefore, likely to present itself.

It follows, of course, that deduction is the easier process ; for, given the premises, only one construction, and consequently only one solution, is possible. "In Induction you are finding out the system piecemeal, in Deduction you already have the clue ; but the system and the system only, is the ground of inference in both. Induction is tentative because we do not know the system completely," whilst "in deduction we are sure of having knowledge which covers the whole system."¹

Both deduction and induction, then, aim at making evident what a system involves. Looked at thus, they are seen to be two sides of one process, and not two separate and opposed kinds of inference. Every system is built up on inductions, for our universals

¹ Bosanquet, *Essentials of Logic*, p. 162.

are found by analysing experience; deduction, therefore, implies induction. On the other hand, as we shall see later on, induction involves deduction;¹ consequently, when we examine the processes in detail we shall begin with deduction.

§ 12.—Induction and Deduction are, indeed, but expressions for those fundamental and mutually involved processes of analysis and synthesis which we have already found to be implicit in every judgment, that is, in every expression of knowledge or belief.

Analysis
and Syn-
thesis.

We are now in a position to see more clearly what is meant by saying that each of these implies the other. Induction is primarily analytic, because it works by analysing or mentally separating the elements which compose a given fact. But it is also synthetic, "for we not only get internal connexions in our given material, but travelling beyond it, we take it as one member in a group of instances. Beginning with the individual case we are investigating, we go on to others of the self-same nature."² These others we bring under the universal law we have found, or, in other words, we include them in the system we are constructing. On the other hand, deduction is primarily synthetic, as it is ostensibly this very process which we have just seen to be implicit in induction. But by following out the universal relations of a system into its details, we are analysing that system unawares, and turning the vague idea of it with which we started into clear and definite knowledge. As Mr. Bradley admirably puts it: "Analysis is the synthesis of the whole which it divides, and synthesis the analysis of the whole which it constructs."³ These two are, then, different sides of one process, the object of which is to show a system

¹ See ch. x. ² Bradley, *The Principles of Logic*, p. 435.

³ *Ibid.*, p. 431.

as a clearly articulated whole. They differ in starting-point, in the end in view, and in the mental process of which we are conscious. But when the result is reached, it is always apparent that it has the two-fold character of exhibiting at once the unity of the whole and the differences of its parts. Advance in knowledge is, then, advance in both analysis and synthesis. "The more deeply you analyse a given whole, the wider and larger you make its unity; and the more elements you join in a synthetic construction, so much greater is the detail and more full the differentiation of that totality."¹

Analytic
and
Synthetic
Methods.

§ 13.—It follows from what we have said that whether the analytic or the synthetic method is mainly adopted in any particular science depends upon the extent to which that science has been organized as a system. The more fully this has been done, the more deductive inference preponderates, for the more possible it is to start fresh enquiries from universal relations which have been previously established. On account of its very abstract nature and the simplicity of the axioms on which it is based, mathematics is the most deductive of the sciences, and the more any particular science is able to bring itself into touch with mathematics the more the synthetic method takes the place of the analytic method in that science. Physics and astronomy have in this way, become mainly synthetic in method. On the other hand, biology is still largely analytic in its method, though the adoption of the great principle of evolution is gradually making it more synthetic. Geology and chemistry are still compelled to follow mainly the analytic method, whilst history, based as it must always be on testimony, can probably never do anything else.

¹ Bradley, *The Principles of Logic*, p. 447.

CHAPTER IX

DEDUCTIVE INFERENCE

§ 1.—Deductive Inference is the establishment of some particular relation by placing it in an appropriate system. Now this may be done with greater or less definiteness. We may be able to say no more than that we have a case which falls under a certain system, without being able to construct that system in detail. Then the inference is one of *Subsumption*, which simply means that it sets forth a particular as an example of a universal. Such an inference is based upon the relation of subject and attribute, that is, upon the assertion that a certain concrete subject possesses a certain attribute, as “Wolves are savage,” or “Slavery is derogatory to human nature.” But of a concrete subject many such assertions are possible. It is because of this concrete character, that no single construction can give us the whole system, and it follows that in every subsumptive inference it is necessary to state explicitly which of the universal relations involved in the system is made the basis of the inference.

Kinds of
Deductive
Inference.

In other cases the relations involved are much more definite, because they are purely abstract.

Then the whole nature of the system stands revealed by the combination of the given elements, and it is not necessary to restate that nature in a more abstract form. In such cases the inference may be simply called one of *Construction*; the best examples of this are found in geometry and other branches of mathematics. We must consider these two forms of deductive inference separately.

SYLLOGISM

Nature of
Syllogism.

§ 2.—*Subsumptive Inferences* were fully analysed by Aristotle, and the results set forth in the doctrine of the *Syllogism*. Aristotle defined syllogism as “a form of reasoning in which certain facts being assumed, something else differing from these facts, results in virtue of them.” Stated explicitly, a syllogism consists of three parts—(1) the *Major Premise*, which sets forth the universal relation on which the whole construction rests; (2) the *Minor Premise*, which brings a particular case under the major; (3) the *Conclusion*, which sets forth the necessary consequence of this combination of premises.

Distributed
Middle
Term.

Now it is evident from this statement that the premises must have an element of identity as a connecting link. This is embodied in the *Middle Term*, that is, the term which is common to both premises, and by means of which the minor is subsumed under the major. Symbolically then, we may state a syllogism thus—

Major Premise	M is P,
Minor Premise	S is M;
Conclusion	∴ S is P.

The first essential of syllogistic inference is, then,

that *there should be an identical middle term connecting the premises*. This can only be *formally* secured by obeying the traditional rule that "the middle term must be used in its full extent in at least one of the premises," that is, that there must be a definite assertion about *every* M. If we have as premises "Some oranges (M) are sweet (P)" and "This (S) is an orange (M)," we can draw no certain conclusion as to the sweetness or otherwise of this particular fruit, though doubtless we shall think its sweetness more or less probable. Some amount of such weakness belongs to every major premise which is merely derived from experience and does not rest on a necessary connexion of attributes. "He is a fool," says Mrs. Poyser, "who can see the cat go into the dairy and ask what she has gone there for." Here, no doubt, experience is strengthened by a knowledge that cats like cream, but the conclusion that every time a cat enters a dairy its intentions are felonious is not a necessary one, though its probability is sufficiently strong to justify immediate action on that conclusion. Thus it is evident that the strength of conviction with which we accept a conclusion is proportionate to the amount of probability we feel as to the M being really identical in our premises.

The traditional doctrine of syllogism rejected all inferences which do not give a certain and definite conclusion. This was a natural thing to do when it was believed that ultimate truths of a self-evident character could be found in every department of knowledge. The nature of some of these 'truths' has already been indicated.¹ We no longer believe in such a mechanical road to knowledge, and we are conscious that the majority of our conclusions,

¹ Cf. p. 113.

though probable enough for all practical purposes—that is, as guides to action of various kinds—are yet not supported by evidence so cogent as to make them absolutely certain. An investigation of the method of knowledge must, therefore, take account of inferences which only yield more or less probable conclusions. So long as we are careful to distinguish between conclusions which are certain and those which are only probable, no fallacy is committed.

But it may be asked—Is the formal rule to refer explicitly to “every M” the only way of securing that M is identical in both premises? To this the answer is that if the major really rests on a necessary connexion of attributes, the M can always be thus expressed. Science, as we have seen, aims at establishing reciprocal judgments.¹ When such a judgment has been established it is a matter of indifference which term is made the grammatical subject and which the predicate of the proposition which expresses it. There are many such judgments in chemistry. For example, a liquid is tested by dipping into it a piece of blue litmus paper; if the paper turns red, the conclusion is drawn that the liquid tested is an acid. The inference would probably be set forth in this form—

All acids (P) turn blue litmus paper red (M),

This liquid (S) turns blue litmus paper red (M);

Therefore, this liquid (S) is an acid (P).

Thus stated the syllogism is formally invalid because no explicit reference is made to “every M” in either premise. But as the major is a reciprocal judgment, it may be equally well expressed in the form, “All liquids which turn blue litmus paper red are acids,” and if this is put as the major premise the formal flaw disappears. Of course it is only because

¹ Cf. p. 88.

the major is reciprocal that this change of form is allowable. We must conclude, then, that no syllogism is valid unless it can be stated in a valid form.

The second essential of syllogistic inference is that *the conclusion must not assert more than is warranted by the premises*, a requirement which syllogism shares with all other forms of inference. If, under the general major "Every M is P," we bring as minor "This S is M," or "Some S's are M," it is evident that we should only refer in the conclusion to just the very same S or S's. We can only draw a conclusion about "every S" when the minor premise definitely refers to every S. Or, to put it in another way, from a minor "S may be M," united with a major "M is P," we can only conclude that "S may be P." As there is no necessary connexion affirmed in the minor, none can be asserted in the conclusion.

*Conclusion
warranted
by Premises.*

Similarly, the whole scope of P can only be referred to in the conclusion when it is definitely referred to in the major premise. Such explicit reference to the whole application of the predicate is only possible in a negative judgment, and there it is always made. Hence, to infer from the premises "All fishes (M) are cold-blooded (P) ; No whales (S) are fishes (M)," that "No whales (S) are cold-blooded (P)," is an invalid inference, though both premises and conclusion happen to be true. And this draws our attention to an important point, namely, that the validity of a syllogism is not to be tested by the truth or falsity of its conclusion, but by whether the premises warrant that conclusion. A good position may be supported by very bad arguments, and in such cases the construction offered as its support is not the evidence on which its truth really rests. Of course, the question as to the truth of our premises is one of

equal importance with the question as to the validity of our inference, but it is one which syllogism does not attempt to answer. The characteristic of syllogism is that it starts from premises assumed to be true; the grounds for such assumption must usually be sought in induction.

Validity of
Syllogism.

The requirement that the conclusion must not go beyond the premises in the scope of its assertion raises the question whether such a construction is a valid inference at all. It has been urged that if from the premises "Every M is P," "S is M," we draw the conclusion "S is P," we are guilty of the fallacy of *petitio principii*.¹ Doubtless if our major premise rested on an exhaustive enumeration of instances, as its mere form suggests, we should not be justified in asserting it unless we had examined S among other instances of M, and so this charge would hold. But when we remember that the real justification of the major is a known necessary connexion of S and P, then the charge is seen to be itself a *petitio*, as it assumes the very point to be proved, viz., that the major is the result of a complete enumeration of instances of M. I may know that every candidate who gets less than x marks in mathematics fails in a certain examination, and this knowledge is quite independent of whether I am acquainted with the marks actually scored by any of the candidates who do fail. The major is based on the regulations applicable to the examination, and is the real and true ground of the failure of all candidates who fulfil the condition it lays down.

Again, it has been urged that syllogism is not inference, because immediately we have the premises we have the conclusion. It may be replied that if this were not so it would not be inference, for the

¹ Cf. p. 112.

essence of all inference is that the premises necessitate the conclusion. This objection is based on two confusions. The first is that looking upon novelty as the essence of inference, which has been already dealt with.¹ The other is the confusion between the judgments which form the premises as mere judgments, and as premises. As mere judgments—that is, as separate from each other—neither of them involves the conclusion. When they are combined as premises the conclusion is the necessary consequence not of the judgments but of their combination.

The remaining rules of syllogism are self-evident and need not detain us. They are that *one premise must be affirmative*, and that *an affirmative conclusion can only be the outcome of two affirmative premises*. As a negative judgment explicitly denies a relation, it is evident that two such denials of relation to M can establish nothing. And equally evident is it that a denial in the premises must be represented by a corresponding denial in the conclusion, and *vice versa*.

Minor Rules
of Syllo-
gism.

§ 3.—Aristotle considered in detail how many combinations of premises would yield valid syllogisms, but the enquiry is mainly of antiquarian interest. Any construction which claims to be a syllogism can be tested by the four rules we have considered above.

Forms of
Syllogism.

One other point only needs be noticed, and that is the distinction of *Figure*. Aristotle distinguished three figures according to the position of the middle term in the two premises—

	FIG. I.	FIG. II.	FIG. III.
Major Premise.....	M—P	P—M	M—P
Minor Premise.....	S—M	S—M	M—S
Conclusion.....	∴ S—P	∴ S—P	∴ S—P

¹ Cf. pp. 116—117.

Of these only the first is really an analysis of subsumptive inference, for it alone has a true major premise; that is, a universal under which the minor is brought. In the other figures the premises are the same in kind, and this involves that they cannot give a certain universal affirmative conclusion. Their most important function in the method of knowledge is that they are steps in induction. We shall, therefore, postpone further consideration of them to a later stage.¹

The mediæval followers of Aristotle added a fourth figure showing the remaining possible arrangement of terms—

Major Premise	P—M
Minor Premise	M—S
<hr/>	
Conclusion.....	∴ S—P

This is certainly a possible symbolic form, but it corresponds to nothing in the actual structure of thought, and should, therefore, be discarded.

Hypo-
thetical
Syllogisms.

§ 4.—The universal judgment, as we have seen, is often most exactly expressed in hypothetical form. We may, then, have syllogisms in which the minor premise brings a particular case under a universal relation of the form “If S is M it is P.” Now from this mere form we must not assume that M is the only possible condition under which S is P, for in most of the judgments of ordinary life neither M nor P are stated with sufficient accuracy.² We must, then, face the possibility that S may be P under other conditions, as X, Y, Z. For instance, “If a man (S) is shot through the heart (M) he dies (P),” but there are many other possible causes of death. It follows that we cannot infer “S is not P” from the conjunction of such a major premise with a minor of

¹ See Chaps. xi. and xiv.

² Cf. pp. 88, 90.

the form "S is not M"; for S may be X or Y or Z, and in either of these cases it is P. Again, the assertion "S is P" united as minor with the major "If S is M it is P" will not justify us in asserting "S is M," for P may in this case be due to X or Y or Z. We have then only two forms of syllogism with a hypothetical major premise which yield a certain conclusion. They are—

- (1) If S is M it is P,
But S is M;
Therefore, S is P.
- (2) If S is M it is P,
But S is not P;
Therefore, S is not M.

To put it generally : a certain and definite conclusion can be drawn from either affirming the antecedent or denying the consequent of the hypothetical major premise. But to deduce such a conclusion from denying the antecedent would be to commit a formal fallacy analogous to the illicit extension of the reference of the major term in categorical syllogism. This is evident when it is seen that every hypothetical syllogism can be expressed categorically by writing the major premise in the form "Every S M is P." The minor "This S is not M" may be expressed: "This is not S M." If then these two propositions are combined

Every S M is P,
This is not S M;

it becomes evident that we are not justified in concluding "This is not P."

Similarly, if we affirm the consequent, the syllogism may be categorically expressed

Every S M is P,
This is P ;

and it is seen that the middle term P is not distributed and consequently we are not justified in affirming "This is S M."

Hence, it is a matter of indifference, so far as the formal accuracy of our inference is concerned, whether we state it in a categorical or in a hypothetical syllogism.

CONSTRUCTION

Nature of
Construction.

§ 5.—We must now consider the characteristics of *Construction*. In such inferences as "A is north of B and B is north of C, therefore A is north of C," the conclusion follows obviously and immediately from the construction. But that construction is not syllogistic, for there is no middle term; we have "B" in one premise and "north of B," in the other. No doubt we can put the whole into syllogistic form by using as a major "What is north of anything is north of that which the former is north of." But this is merely the construction itself generalized and put in a more abstract form; it is not the ground on which the inference actually rests. In such inferences, as in all others, we must have a point of connexion between the premises. But the mere presence of the same term in each is not enough; that term must stand in the same kind of relation in each. As Mr. Bradley says, "'A runs faster than B and B keeps a dog (C),' 'A is heavier than B and B precedes C,' 'A is worth more than B and B is on

the table (C),’ or ‘A is like B and B is like C.’ You may doubtless extract some kind of inference out of these premises, but you can hardly go from them to any definite and immediate relation between A and C.”¹

Now, it is evident that the relations between things are indefinite in number, and consequently it is impossible to make a list of valid inferences. All that can be done is to consider the “tests of the general possibility of making a construction; but of the actual construction there can be no canons.”²

§ 6.—The general principle of such constructive inferences is that the construction exhibits the whole contents of the system. They are of two main classes (1) those in which the constructed whole is a mere sum of its elements, the typical examples being arithmetical constructions; (2) those in which the elements united are relations, the most typical examples being geometrical constructions. In each case the process can be immediately generalized; for as the whole of the system is explicit in the construction, any precisely similar construction will yield a precisely similar result.

Types of
Construc-
tion—

If we consider the judgments of arithmetic we find they are based on the idea of a unit. Now in counting concrete objects “the mind always chooses its own unit; it groups its objects as it pleases, and chooses as units the groups it has made: sometimes it counts by faggots, sometimes by single sticks.”³ The unit is, then, something determined not by the nature of things but only by the act of mind which discriminates things from each other. Objects altogether unlike in their qualities may be counted if we choose, just because they are alike in this one point,

Arithmetical
Construc-
tions.

¹ *The Principles of Logic*, p. 233. ² *Ibid.*, p. 246.

³ Bryant, *Educational Ends*, pp. 192—193.

that they can be discriminated from each other. Thus, a unit is a purely abstract individuality, and is at bottom nothing but an act of discrimination. Counting may be aided by the presence of concrete objects, but it is independent of their nature; its elements are the mental acts of discrimination. Hence, the constructed whole is purely abstract; the elements and the whole are both made by the mind itself.

Counting is the foundation of arithmetical judgments, and counting, beginning with one unit, is the gradual synthesis of units by adding one at a time, and giving a distinctive name to each new whole. But, as we have seen, all synthesis involves analysis, and the whole constructed is, by that construction, seen as the sum of its units. It is, of course, also apprehended as a whole of a certain definite character which distinguishes it from other wholes. It is because of these various characteristics that an arithmetical operation is an inference. "In these cases we are given certain elements, and assert that these elements form a certain whole. Both the elements and the whole must be such as to be known *otherwise than in relation to each other*, or we get into tautology. Thus, if 8 only meant $5 + 3$ the statement $5 + 3 = 8$ would be an idle play on words. But 8 also means $4 + 4$, $10 - 2$, 4×2 , and I will venture to say that it also and primarily means 8."¹

The primarily analytic operation with number is that of measuring, and this also rests on the conception of a unit. The object of measuring is to reduce what is given as a whole to a multiplicity of units, in order to compare it in respect of quantity with another whole similarly treated. Of course as a

¹ Hobhouse, *The Theory of Knowledge*, p. 424.

result the whole is apprehended as a synthesis of the units by which it is measured. It is unnecessary to pursue the subject further, our aim being only to make clear the character of the inference.

Very few words need be added on constructions of spatial relations. If we are given the definite spatial relations—that is, the distance and direction—of both A and C to B, our construction, whether it remains purely mental or is aided by drawing a diagram, makes evident the spatial relation of A and C. All inference from charts and maps and plans is of this character. It is on constructions of this kind that the validity of geometrical axioms rests.

*Geometrical
Construc-
tions.*

§ 7.—As both arithmetical and geometrical constructions can be immediately generalized, they have an inductive aspect. Indeed, there is reason to suppose that “mathematics in their primitive stages would have a *quasi*-inductive character. That is to say, that (1) they would tend to deal with concrete objects, or classes of such objects; that (2) their results would have the aspect of independent generalizations, rules of thumb, and so on; and that (3) they would be encumbered with difficulties in rising from these first generalizations to higher, more comprehensive, and more abstract principles. All these points seem to be borne out by the little that is known, or probably inferred, as to the early history of arithmetic and geometry.”¹ The bearing of this on the method of teaching these subjects to children is obvious.

*Inductive
Aspect of
Construc-
tion.*

¹ Hobhouse, *op. cit.*, p. 436.

CHAPTER X

OUTLINE OF INDUCTIVE METHOD

Meaning of
'Induc-
tion.'

§ 1.—INDUCTIVE inference starts with particular facts and proceeds by a process of analysis to find the universal relations they embody, and so to construct a system whose nature explains them. The word 'Induction,' however, has been used, and, indeed, still is used, in more than one sense. Aristotle confined 'induction' to generalization from sense-perception: "Induction begins with facts of personal experience and reasons backward to the cause or principle."¹ But such reasoning does not give really scientific knowledge, the appropriate expression of which is the syllogism. This is admirably put: "Nor is it possible to obtain scientific knowledge by way of sense-perception. For even if sense-perception reveals a certain character in its object, yet we necessarily perceive *this, here, and now*. The universal, which is throughout all, it is impossible to perceive; for it is not a *this-now*; if it had been it would not have been universal, for what is always and everywhere we call universal. Since then demonstration (science) is

¹ *Anal. Pr.*, II, 68, b., 32.

universal, and such elements it is impossible to perceive by sense, it is plain that we cannot obtain scientific knowledge by way of sense.”¹

It is just this establishment of universals which is the aim of modern science, and it is becoming more and more usual to apply the term ‘induction’ to the whole process, instead of restricting it to that mere suggestion of a universal by sense-perception which corresponds to Aristotle’s use of the term. ‘Induction’ in this wide sense corresponds to the whole method of attaining knowledge, and includes deductive processes.

§ 2.—Using the word in this wide sense, the question is, How can the universal be found in the particular? Not by sense-perception or observation, as Aristotle has so clearly shown in the passage quoted above. The universal can only be found by thought, that is, by supposing the existence of a certain law and then testing this supposition. As De Morgan tersely puts it: “A few facts have suggested an *hypothesis*, which means a *supposition* proper to explain them. The necessary results of this supposition are worked out, and then and not till then, other facts are examined to see if these ulterior results are found in nature.”² The main steps of inductive method, may, therefore, be thus stated—

General
Method of
Induction.

1. A preliminary observation of facts.
2. The formation of a hypothesis suggested by this observation.
3. The testing of the hypothesis by comparison of its consequences with the results of a careful analysis of phenomena, with modification or even

¹ *An. Post.*, 87, b., 28, quoted by Bosanquet, *Ess. of Logic*, p. 154.

² *Budget of Paradoxes*, p. 55.

rejection if necessary. This process is carried on till the hypothesis is proved, when it is more correctly called a *Law* or *Theory*, according to whether it states one universal relation or is a wider generalization covering many laws.

It is in the third step that deduction is continually operative, for, as Dr. Bosanquet says, "nothing can be more deductive than the connexion of a hypothesis with the consequences by which it is verified."¹

Direct and
Indirect
Testing of
Hypotheses.

§ 3.—The testing, moulding, and verification take a more direct, or a mainly indirect, form according to the nature of the case. When we are investigating a causal sequence in which the cause is simple and under control, we may try experiments with it, and our verification is a comparatively direct process. Even though the cause is not under our control, yet if the whole causal sequence can be observed under varying conditions, the process of testing and verification still remains partially direct. In this case, however, the more indirect method of deductively inferring the probable consequences of the cause and looking about to find if these consequences are really to be found in nature, will also be adopted. In all other cases this indirect method must be used nearly or altogether exclusively. "A cause . . . may be under control and yet be too dangerous to experiment with; such as a proposed change of the constitution by legislation; or even some minor Act of Parliament, for altering the Poor Law, or regulating the hours of labour. Here the first step must be deductive. We must ask what consequences are to be expected from the nature of the change (comparing it with similar changes), and from the laws of the special circumstances in which it is to operate? And sometimes we may partially verify

¹ *Logic*, vol. ii, p. 119.

our deduction by trying experiments upon a small scale or in a mild form.”¹

When the facts with which we start are effects, and the causal sequence cannot be observed but must be inferred from those effects, as, for example, is mainly the case in geology, then the indirect method of verification is the only one available.

¹ Carveth Read, *Logic, Deductive and Inductive*, p. 164.

CHAPTER XI

OBSERVATION

Importance
of Observa-
tion.

§ 1.—THE scientific method of knowledge starts with facts and continually returns to facts to test and verify its hypotheses. If its supposed facts are fictions, the whole fabric falls to the ground. It is a fundamental question, therefore, how an accurate knowledge of facts is to be obtained, and to this there is but one answer—by exact observation. Every statement of fact rests directly or indirectly on observation. In the former case, the only question is as to the correctness of the observation ; in the latter case we must add to this an enquiry into the competence and trustworthiness of the witness who records it. In the present chapter we are concerned only with direct observation.

Liability
of Observa-
tion to
Error.

§ 2.—At first sight it might seem that nothing need be said on this point. “Seeing is believing” is a proverb accepted by many as axiomatic. And, indeed, taken as expressing a common fact in the natural history of many minds, it is undeniably true. We are naturally apt to believe what we see, or rather, what we believe we see. But the mere fact of belief, as has been more than once insisted

on, is no sufficient evidence of the truth of the judgment believed; and what is commonly called "the testimony of the senses" is by no means infallibly accurate. Every case of illusion is an instance of this. As Aristotle long ago pointed out, a pea appears double when it is placed between two crossed fingers of one hand and then rolled about. Again, the two flat pictures in a stereoscope combine into an appearance of solidity. An immense number of other instances could be given. Further, the testimony of the senses is apt to contradict itself. "The moon at its rising and setting appears much larger than when high up in the sky. This is, however, a mere erroneous judgment; for when we come to measure its diameter, so far from finding our conclusion borne out by fact, we actually find it to measure materially less."¹ Nor is such false testimony of the senses confined to individual experiences. "A vague and loose mode of looking at facts very easily observable, left men for a long time under the belief that a body, ten times as heavy as another, falls ten times as fast; that objects immersed in water are always magnified, without regard to the form of the surface; that the magnet exerts an irresistible force; that crystal is always found associated with ice; and the like."²

§ 3.—The possibility of such wide-spread errors as those of which Whewell here gives a few examples, proves that men are generally bad observers, and, as a consequence, that mere extended observation is no guarantee of truth. It is not how often an observation has been made, but how accurately it has been made, that is the important point. And the accuracy which science demands is only possible

Dependence
of Observa-
tion on
Previous
Knowledge.

¹ Herschel, *Discourse on Natural Philosophy*, § 72.

² Whewell, *Novum Organon Renovatum*, p. 61.

when the observer possesses special skill and knowledge. "A person may well derive, perhaps in some unfamiliar department of knowledge, a degree of certainty from the affirmation of the qualified expert far surpassing anything he could reasonably derive from his own imperfect or untrained observation."¹ Observation, in other words, is not a mere matter of perfect sense-organs, even when these are united with a concentrated attention and an earnest purpose to observe well. Only he observes well who brings much pertinent previous knowledge to the observation. "To make a perfect observer," says Herschel, "an extensive acquaintance is requisite, not only with the particular science to which his observations relate, but with every branch of knowledge which may enable him to appreciate and neutralize the effect of extraneous disturbing causes."²

Observation
and In-
ference.

§ 4.—This leads us to the very essence of the matter: observation always involves inference, and the correctness and value of every inference depends upon the truth and adequacy of its premises. For by 'observation' we mean not the mere reception of sense-impressions, but the selection from amongst the whole mass of such impressions of those to which we will attend, and the interpretation of those attended to. And both selection and interpretation are matters of inference.

Selection.

When we select a phenomenon for observation we disregard a great deal more than we attend to, and we assume that this abstraction will not alter the character of what we are studying. But this assumption is a matter of inference and may be erroneous. In the seventeenth century Sir Kenelm Digby won much fame by the cures of wounds wrought by his

¹ Ravenshear, Article on *Testimony and Authority*, Mind, N. S., vol. vii, p. 65.

² *Op cit*, § 127.

sympathetic powder. Says De Morgan: "The sympathetic powder was that which cured by anointing the weapon with its salve instead of the wound. I have long been convinced that it was efficacious. The directions were to keep the wound clean and cool, and to take care of diet, rubbing the salve on the knife or sword. If we remember the dreadful notions upon drugs which prevailed, both as to quantity and quality, we shall readily see that any way of *not* dressing the wound would have been useful."¹ Similarly, "to-day, the Suffolk farmer keeps the sickle with which he has cut himself free from rust, so that the wound may not fester."² The error, as these examples show, may be either in excluding elements which ought to be included, or in including as essential those which are immaterial. This matter of selection is, indeed, one of the most difficult in scientific discovery, and we shall have to consider it in more detail in a later chapter.³ All we wish to make clear at this point is that whether an element should be included as important, or excluded as irrelevant, to the matter in hand is an inference from the knowledge which the observer brings to the observation.

All interpretation is also inferential, for it involves a reference to what is not now given in sense-perception. As an example let us consider the simplest possible case—that of recognition. We see a small yellow sphere of a certain size and we immediately recognize it as an orange. Doubtless, we are unconscious of any mental process, and so from the psychological point of view we might refuse to call it inference at all. But it has been already pointed out that the question for logic is the kind of

Recogni-
tion.

¹ *Budget of Paradoxes*, p. 66.

² Clodd, *Tom Tit Tot*, p. 64.

³ *Cf.* Ch. xiv.

evidence on which a judgment rests: if that is a mental construction from which a result necessarily follows we have inference. Now, the judgment "This is an orange" as an interpretation of the sight-perception we have spoken of, can only be justified by a construction such as the following—

Oranges are spheres of a certain size and appearance,
This is a sphere of such size and appearance ;
Therefore, this is an orange.

Here the inferential character of the evidence on which our judgment rests appears plainly in the form of a syllogism in the second figure.¹ But further, our conclusion carries much more with it than the visual qualities on which it is based. In calling the object perceived an 'orange' we infer that it possesses many other qualities, as those of taste and smell and touch. And to this inference a very practical conclusion would be given by eating the orange. If we examine this second inference we shall find that it falls naturally into a syllogism in the first figure—

Oranges are sweet, juicy, &c.,
This is an orange ;
Therefore, this is sweet, juicy, &c.

Now, if these two syllogisms are examined it will be seen that both are formally invalid, in that in neither is the middle term used universally. The conclusions drawn should then not be stated as certain but as only probable—"This is probably an orange"; "This may be (*or* is probably) sweet." But it will also be noticed that the conclusion in the

¹ Cf. p. 129.

former case is much more likely to be true than that in the latter, because the signs by which the object is classed as an orange are of a definite character and have been directly observed. It is possible that a waxen or stone image might be made to resemble an orange so closely in visual appearance that it might deceive all but the most careful and minute observers. But the test of the other senses is an easy one to apply and is decisive. Such verification involves an inference in the first figure such as we have quoted above, and the comparison of its conclusion with a new sense-impression.

If the inferred qualities are found to be absent, as in the case of the waxen or stone image, then the recognition from which they were inferred is rejected as unwarranted. This rejection, like the original recognition, can be analysed into a syllogism in the second figure—

Oranges are sweet, juicy, &c.,
This is not sweet, juicy, &c. ;
Therefore, this is not an orange.

Here the conclusion is certain, as the middle term is used universally in the negative premise, and so there is no such formal invalidity as in the former case.

The inference in the first step of recognition is altogether implicit. Psychologically it is due to the habitual association of a certain group of attributes which we have learnt to sum up under the term 'orange,' an association so perfectly mechanical that the presence of one or two of those attributes immediately suggests the whole group. But this suggestion is vague ; no one attribute is singled out, and the only thing in full consciousness besides what is given in sense-perception is the name.

If we now turn to the second step we see that the

inference involved is somewhat nearer to being made explicit. From certain visual appearances we infer the presence of some definite non-visual quality or qualities, and we do so on the ground of their common inherence in the object we have recognized. There are, therefore, two chances that our conclusion is not true; for the act of recognition may be unjustified, and, even if it is justified, our major premise may not be universal when we believe it to be so. The young child, for example, with experiences of only sweet oranges, would doubtless expect with the utmost confidence that any fresh example of orange would also be sweet; the adult would know that this is open to considerable doubt, and would take for his major premise only the limited judgment "Some (or most) oranges are sweet." Now, when the child has his first experience of a sour orange, another conclusion is forced on him, and this also can find its justification in a syllogism, this time in the third figure—

This is sour,
But this is an orange;
Therefore; oranges may be sour.

Thus he proceeds to make his knowledge more exact and definite by forming sub-classes in his previously wide and vague class 'oranges.'¹

The analysis which we have here applied to a very simple example holds true of every case of sense-perception. It shows that even in sense-perception we have all the essential features of the inductive method. The original recognition—liable to doubt, as we have seen it to be—is the hypothesis sug-

¹ This connexion of sense-perception with syllogism was first worked out by Dr. W. T. Harris; see his *Psychologic Foundations of Education*, pp. 62—89.

gested by a first observation of the facts ; then follows the inference of the results of that hypothesis, the testing of those results by further sense-experience, and the consequent verification, modification, or rejection of the hypothesis. The most complex case of induction only contains the same steps, carried out, however, with infinitely greater difficulty and with infinitely greater liability to error, because the matter dealt with is infinitely more complex.

Our analysis shows also that the possibility of error in observation is due to the inferential character of the process, whilst the fact that the inference is largely unconscious renders it easy in cases of any considerable complexity for error long to escape detection. But our analysis has also made it plain that inference enters into the process in varying degrees ; there is less of it in the simple recognition than in the conclusion from that recognition that any particular quality, such as sweetness, will be found. Now it is evident that this second step may be developed to any extent, and may extend to conclusions which cannot be immediately tested by the senses. It is here that ordinary convention draws the line between 'observation' and 'inference.' So long as we remember that observation itself involves inference, this distinction is a useful one. Suppose that, having recognized the orange, I drew the conclusion that it had been grown in Tangiers, that would obviously be an inference. Now, nothing would seem simpler than to distinguish between observation and inference in this sense of the terms. Yet nothing is more common than to confuse them. "Not one eye-witness in a hundred can adequately distinguish what he saw or heard from what he inferred."¹ The reason should now be evident. It

Distinction
between
'Observa-
tion' and
'Infer-
ence.'

¹ Hobhouse, *The Theory of Knowledge*, p. 215.

is that psychologically such an inference as that the orange came from Tangiers, and such a judgment as "the orange is probably sweet," rest on evidence of the same sort, that is, evidence drawn from the previous knowledge of the observer. Logically, there is the difference that the latter deals with something which is directly given and so can be immediately tested by sense-experience, whilst the former asserts what is not so given and cannot be so tested.

An illustration of our point may be drawn from Dr. Conan Doyle's ideal embodiment of the powers of precise observation and accurate inference, Mr. Sherlock Holmes. In the introduction to *The Sign of Four* his ingenuous biographer, Dr. Watson, writes—

" 'You spoke just now of observation and deduction. Surely the one to some extent implies the other.'

'Why, hardly,' he answered, leaning back luxuriously in his arm-chair, and sending up thick blue wreaths from his pipe. 'For example, observation shows me that you have been to the Wigmore Street Post-office this morning, but deduction lets me know that when there you despatched a telegram.'

'Right!' said I, 'Right on both points! But I confess that I don't see how you arrived at it. It was a sudden impulse upon my part, and I have mentioned it to no one.'

'It is simplicity itself,' he remarked, chuckling at my surprise—'so absurdly simple that an explanation is superfluous; and yet it may serve to define the limits of observation and of deduction. Observation tells me that you have a little reddish mould adhering to your instep. Just outside the Wigmore Street Office they have taken up the pavement and thrown up some earth, which lies in such a way that it is difficult to avoid treading in it in entering. The

earth is of this peculiar reddish tint which is found, as far as I know, nowhere else in the neighbourhood. So much is observation. The rest is deduction.'

'How, then, did you deduce the telegram?'

'Why, of course I knew that you had not written a letter, since I sat opposite to you all the morning. I see also in your open desk there that you have a sheet of stamps and a thick bundle of post-cards. What could you go into the post-office for, then, but to send a wire? Eliminate all other factors, and the one which remains must be the truth!''

We are afraid that Mr. Sherlock Holmes fails here to justify the tone of somewhat supercilious superiority which he adopts towards his friend. He begins by pooh-poohing a perfectly accurate remark of Dr. Watson, and he ends by a very unsafe inference, for he forgets to "eliminate" many factors, such as the purchase or the cashing of a postal order. But we have quoted the passage because he falls into the very confusion between observation and inference—or "deduction" as he calls it—which he has undertaken to show Dr. Watson how to avoid. In the ordinary sense of the words he observed the mud on his friend's boot; he did not observe, but inferred, the visit to the post-office. And according to his own principles that is where he should have drawn the line.

§ 5.—Our investigation has shown us clearly that observation is always relative to the previous knowledge of the observer, and that it is accurate and fruitful exactly in proportion to the thoroughness and correctness of that previous knowledge. When the previous knowledge is vague and indeterminate, the observation is wanting in definiteness and in depth, and is unfruitful in inferential results. When instead of knowledge, or mixed up with knowledge, there is

Observation
and
Prejudice.

a mass of unfounded belief, the observation is vitiated by bias and prejudice. The danger of not keeping out this element of error is one against which only the trained mind is on its guard. The savage interprets all his experiences in accordance with his superstitions, and so finds his false beliefs everywhere confirmed by his observations. His cattle sicken and die under the influence of the "evil eye" unless he can get a stronger counteracting charm thrown over them. In these more civilized times men still believe in dreams and omens, and support their belief by instances they have observed, dwelling on a few cases of more or less close resemblance between a dream and some following event, and ignoring the enormous number of cases in which the dream does not "come true." Even the scientific enquirer finds it hard to observe quite fairly facts which make against his pet theories.

Observation
and
Scientific
Instru-
ments.

§ 6.—The dependence of observation on previous knowledge is brought out yet more clearly when observation is aided by scientific instruments, which all embody whole systems of knowledge. The accuracy of observations made with such instruments depends on the knowledge which produced the instrument as well as on that in the observer's mind. And that these are related to each other is shown by the fact that only skilled observers can really make use of very delicate and complicated instruments.

Experi-
ment.

§ 7.—Most strikingly of all is the dependence of observation on previous knowledge brought out when the observation takes the form of what is known as an *experiment*, that is, is made under conditions determined by the observer. The selection which, in ordinary observation, is merely mental is here made physical as well. The object of this selection is to omit all elements which have no

influence on the phenomenon to be observed, and to retain, in known relations to each other, all those that have such influence. An error will vitiate the whole result, and the history of science is full of instances of erroneous conclusions due to the presence of unsuspected conditions which modified the phenomenon observed. It is evident, then, that no one can really experiment who has not extensive knowledge of the kind of phenomena he is dealing with. Whether he himself arranges the physical conditions is immaterial; the essential thing is that he mentally determines those conditions. "Manipulation of the external world is not of the essence of experiment, which simply consists in selection and the purpose to observe, usually implying and resulting in precise knowledge of the conditions." ¹

The advantages of experiment over mere observation are its greater definiteness and its subjection to control. When we can experiment we can observe when we will, without waiting for nature to present us with a specimen of the phenomenon we wish to study, and thus investigation can go on continuously and systematically. Again, when we have the conditions under our control we can vary them at pleasure, and systematically observe the results. In many cases, without experiment the knowledge we now possess would never have been attained. Many natural processes go on so slowly and gently that they escape observation. As Lavoisier remarked, the decomposition of water had been going on ever since the beginning of the world, but had never been observed before the experiments of Cavendish and himself brought it to light. But experiment is not always possible. When the process to be investigated goes

¹ Bosanquet, *Knowledge and Reality*, p. 35.

on very slowly experiment is out of the question. The geologist, for instance, cannot experiment on the nature of the forces which have made the earth's crust what it is, nor the biologist on the evolution of species.

CHAPTER XII

TESTIMONY

§ 1.—IF we examine the origin of our own knowledge, each one of us will find that by far the larger portion of it rests, not on his own personal observation, but on the testimony of others. In many cases such testimony can be directly tested, and its acceptance is then merely a matter of convenience ; as, for instance, when a person who has not quitted England accepts the testimony of others to the existence and characteristics of foreign countries. When the testimony is merely the expression of an opinion derived by inference from facts easily observable, such testing by others is always possible. But there are many cases in which facts cannot be observed again ; and then the acceptance of testimony is a matter of necessity, for without it all advance in knowledge would be impossible. “The uniformities shown in the return of certain of the comets are visible only to those who know how to rely upon records many hundred years old. The uniformities brought to light by statistics are nothing to him who cannot depend on an army of co-workers.”¹ Testimony which can be tested by direct

Necessity of
Testimony.

¹ Ravenshear, *Testimony and Authority*, Mind, N. S., vol. vii, p. 66.

observation need not remain testimony, and so need not detain us. But we must enquire what tests of accuracy it is possible to apply to testimony which can never be thus superseded.

Reception of
Testimony.

§ 2.—The only testimony of this kind is to facts which cannot be again observed. But, as the testimony itself records an observation, it might be thought unnecessary to say anything further about it, and to regard it as simply observation at second-hand. This, however, would neglect the factor of reception of the testimony. When a piece of testimony is offered, we may either accept it, reject it, or remain in doubt about it. In the two former cases we make a judgment as to its truth or falsity, and every such judgment rests on what seems to us sufficient evidence. In the last case we judge that the evidence available is not sufficient either to sustain or to destroy the testimony. In every case, then, we analyse and criticize testimony offered us, and such analysis and criticism is similar in character to the inference involved in the analysis and criticism of our observations, the difference being that it is exercised on judgments made by others instead of on facts forming the material of our own judgments.

As with observation, so with the reception of testimony, adequate knowledge and freedom from bias are essential if the testimony is to mean anything to us, and to be fruitful in our hands. Indeed, owing to the dependence of the meaning of words and sentences on their context, the danger of reading into testimony what is only in our own minds is even greater than that of falling into the corresponding error of confusing inference with observation. The more remote from our own experiences are the events with which the testimony deals, the more difficult is it to avoid misinterpretation. This is

one reason why so much of the history of remote times is of a doubtful character. Another reason is the small number of contemporary documents. And these react on each other; for, as the only safeguard against misinterpretation is adequate knowledge of the times, and as such knowledge itself rests on testimony, it is evident that such testimony must be supported by testimony, and, consequently, the smaller its amount the less is its combined force.

§ 3.—Having interpreted a piece of testimony as well as possible, the next question is whether it is to be accepted or rejected. Here also we must be guided by previous knowledge. The savage and the child are extremely credulous of all that falls outside the narrow range of personal experience. As they have no conception of a systematic universe permeated by law, they find in the abnormal and the supernatural no contradiction to the accepted order of things. And this credulity passes but slowly away. Englishmen of the time of James I. probably found nothing incredible in Othello's "men whose heads do grow beneath their shoulders," and the superstitions still common even in the most civilized countries include many things equally unknown to science. It is, indeed, only the specialist in any subject who is a competent judge of the value of testimony dealing with that subject.

Tests of
Testi-
mony—

Now it is in science that we find the most perfect precision and accuracy to which human knowledge has yet attained. Science accepts nothing on bare authority, and in admitting testimony subjects it to the most rigid tests. In addition to demanding that freedom from bias, good faith, and competence in the observer, with which we dealt in the last chapter, science requires that the observation shall be recorded immediately it is made, and that

the record shall be both full and precise. This is the ideal towards which in other departments of knowledge only an approximation is possible.

In history and in common life the only testimony available is generally that of the ordinary eye-witness, and is more or less vitiated, not only by some or all of the faults of observation, but by confusions due to lapses of memory, which are supplied, often without the consciousness of the witness, by inference or by the play of the imagination; and sometimes even by deliberate fabrication. "The evidence which has been adduced for clairvoyance. . . . would have hung a hundred men, but before the tribunal of science it is as nothing."¹ Even in the law-courts where the testimony of the ordinary eye-witness is sifted in a way impossible in most other departments of life, the standard of acceptance is much lower than in science. And this lower standard is necessary, for in ordinary life we have to act on reasonable presumptions; were we to demand theoretical certainty in every case, life would stagnate. "You cannot leave practical matters open, to all eternity, as you can matters of speculative truth."²

Good Faith.

But though we cannot in most cases wait for absolute proof before accepting testimony, yet we must have some reasonable guarantee of its accuracy. Now, when a statement is false it may evidently be so either with or without the knowledge of him who makes it; a man may intentionally say what is untrue or may simply be mistaken. The questions as to the trustworthiness of the testimony fall then under the two general heads of the good faith and the accuracy of the witness. The former of these is of

¹ Bosanquet, *Knowledge and Reality*, p. 135.

² *Ibid.*, p. 136.

logical interest only so far as it bears on the latter, that is, so far as our acceptance of the testimony rests on considerations as to the truthfulness of the witness. If we can test its accuracy independently, the question whether the assertor believes it or not is of little moment; so long as a statement is false it is not of logical interest to distinguish whether it is a falsehood or a simple falsity.¹ We are concerned, then, with sincerity only in so far as it is evidence of accuracy. And this is well, for nothing is so difficult to decide as good faith. "The accent of sincerity' is the appearance of conviction; an orator, an actor, an habitual liar, will put more of it into his lies than an undecided man into his statement of what he believes to be the truth. Energy of affirmation does not always mean strength of conviction, but sometimes only cleverness or effrontery."²

However, in unsupported testimony the question of sincerity is important. We must then consider whether any of the general conditions which cause men to lie are likely to be operative in this case. We must ask whether falsehood would appear to bring any personal advantage to the witness, whether he is likely to be swayed by fear, vanity, sympathy, antagonism, the desire to please, or the wish to astonish or amuse. We should be inclined to suspect all rhetorical flourishes, all dramatic detail, especially when any considerable time has elapsed between the occurrence of the event and the record of it. "Abundance and precision of detail, though they produce a vivid impression on inexperienced readers, do not guarantee the accuracy of the facts; they give us no information about anything but the

¹ Cf. p. 71.

² Langlois and Seignobos, *Introduction to the Study of History*, p. 162.

imagination of the author when he is sincere, or his impudence when he is the reverse.”¹

Accuracy. Granting the good faith of the witness, we must yet accept a narrative as true only when it endures certain critical tests. The main points to be considered are connected with the competence of the author as an observer and as a witness. The essentials of a good observer were dealt with in the last chapter. In enquiring whether our witness possesses the general prerequisite of freedom from bias, we must consider what sort of prejudices would be likely to influence him, such as those common to his condition in life, state of culture, country, and epoch. Especially is this important in estimating the value of testimony of old writers to the miraculous and extraordinary. Often an examination of a writer's works will show his dominant superstitions, bias, and prejudices, and any statement in which these play a part must be discounted accordingly.

We must next consider the competence of the witness as an observer of the particular facts he records. And here, in addition to questions as to his general competence in observing facts of the kind in question, dependent on his special knowledge and his power of distinguishing between observation and inference, we have to enquire whether he was in a favourable condition to observe these particular facts. The modern newspaper reporter sometimes writes detailed accounts of meetings he has never attended, and ancient and modern historians have embellished their pages with scenes equally dramatic and equally imaginative. When the scenes recorded are complex, much of the detail must be matter of imagination, of inference, or of the report of others. For

¹ Langlois and Seignobos, *Introduction to the Study of History*, p. 162.

example, when a general records his campaigns and his battles it is evident that but a small part of his testimony is really based on his own observations. Similarly, when a historian relates events which occupied long periods of time, or describes customs and movements which were common over a wide stretch of country, he derives much of what he states from others. In all such cases, therefore, a large part of the testimony which is ostensibly given us by one witness is really supplied by an unknown host of collaborators, whose good faith and competence we have no means of judging.

But competence as an observer does not always imply competence as a witness. Some people seem to be constitutionally unable to make an accurate statement. "They are subject to 'chronic inaccuracy,' a disease of which the English historian Froude is a typical and celebrated case. Froude was a gifted writer, but destined never to advance any statement that was not disfigured by error; it has been said of him that he was constitutionally inaccurate. For example, he had visited the city of Adelaide, in Australia: 'We saw,' says he, 'below us, in a basin with a river winding through it, a city of 150,000 inhabitants, none of whom has ever known, or will ever know, one moment's anxiety as to the recurring regularity of his three meals a day.' Thus Froude, now for the facts: Adelaide is built on an eminence; no river runs through it; when Froude visited it the population did not exceed 75,000, and it was suffering from famine at the time."¹ In fact, however, Froude was right in his first two statements. When professedly critical testimony as to existing facts thus fails us, it is obvious that ancient records must be received with caution.

¹ Langlois and Seignobos, *op. cit.*, p. 125.

Probably, however, the most frequent cause of inaccurate testimony on the part of competent observers is lapse of memory. We all know that memory plays us strange tricks. Details drop out, and we frequently unconsciously fill the blanks by constructive imagination and inference. Or we look at the past through spectacles coloured by our personal feelings of sympathy and antagonism. We are apt to attribute to ourselves the actual utterance of the repartee or witticism that has occurred to us later as appropriate to the occasion, and we are constantly liable to misconstrue our own motives of action and to assume as facts the motives we have attributed to others, and from those assumed motives to infer the reality of certain conduct. Indeed, if it is difficult to distinguish inference of the absent from observation of the present, still more hard is it to separate inference of the desirable from memory of the actual. It is for these reasons that memoirs are so frequently distrusted by historians, and that without any reflexion on the good faith of the writer. To guard against these dangers, science demands the immediate record of all observations which are to be offered as testimony to other workers.

Anonymous
Testimony.

§ 4.—It follows from the above that a good deal must be known about a witness before his testimony can be received as at all conclusive evidence to any fact. When a statement is made anonymously these tests cannot be applied. Hence, no rational mind attaches any weight to anonymous letters, for all that is known of the writer—that he has some reason for concealing his identity, and generally wishes to injure another person secretly—makes against his good faith, and leaves his competence a matter of speculation.

This difficulty of anonymity is very great in his-

tory. Unless it can be decided who made a certain statement, and when and where it was made, the testing of the competence of the witness becomes impossible. In modern books these points are usually decided by the title-page, or by other internal evidence, though even that cannot be held to be decisive as to authorship. *Eikon Basilike* claims throughout to be the work of Charles I, though it is quite certain that it is nothing of the kind. In the case of earlier writings, the question of authorship is often a very difficult one to decide. We all know that, in spite of the evidence of the original title-pages, valiant attempts have been made to prove that Bacon wrote the plays attributed to Shakespeare. Without yielding to this wholesale scepticism as to our great dramatist, yet it is certain that some passages in his works are not by his hand, and only criticism can decide which these are. This criticism is based partly on the evidence of other writers, but mainly on peculiarities of style and of structure brought to light by internal examination of the text itself. By similar tests the approximate dates of the different plays are determined.

With ancient documents such a criticism is even more necessary. Of old writings there are usually only copies extant, and these frequently the work of ignorant scribes, full of errors, and often with forged passages interpolated in the text. Such errors and additions can only be eliminated by critical comparison of independent documents, that is, of documents which are not copies of the same copy. The great principle in deciding independence is that common errors may be assumed to have a common origin. "It is inconceivable that several copyists, independently reproducing an original free from errors, should all introduce exactly the

same errors ; identity of errors attests community of origin." ¹

Corrobor-
ation of
Testimony.

§ 5.—All corroboration of testimony, indeed, to be of value must be independent. The law recognizes this, and refuses to accept mere hearsay, or inference, or evidence which is shown to be the result of collusion. Cross-examination is the most powerful weapon for detecting falsification, as well as for separating observation from inference and hearsay. When false testimony is manufactured it is apt to be too consistent with itself and more or less inconsistent with known facts. As to the first point, it is a commonplace of human nature that no two persons ever give from memory identical accounts of any event they have witnessed in ordinary life ; thus, too precise an agreement in details between witnesses suggests collusion rather than truth. That corroboration is the most above suspicion which agrees on the main points, but not on all the details of accompanying circumstances. Such concurrence of testimony receives additional strength when it is evident that the different witnesses have conflicting interests, or opposed sympathies, in the matter.

With regard to the second point, it is very unlikely that a manufactured story should take account of all the facts it may be brought into relation with, and it is in testing it by such facts that a cross-examiner shows his skill. Cross-examination is, then, a valuable process of sifting the true from the false in oral testimony, though it has its own peculiar danger. A question nearly always suggests a certain kind of answer, either by its form, or by the context in which it occurs, or by the manner and tone of the questioner. This suggestion acts unconsciously on the mind of the person questioned and tends to

¹ Langlois and Seignobos, *op. cit.*, p. 81.

modify the answer given. Some questions, of course, do this more markedly than others, and in the law courts these are ruled out by the judges as "leading questions."

Cross-examination cannot, however, be applied to the dead authors of historical documents. We must, therefore, test their accuracy by certain more or less general considerations. Any of their statements may be accepted as probably true when the facts are such as to reduce liability to error or deception to a minimum. If the author had no conceivable motive to lie, or if the fact asserted was in itself so prominent as to make detection of falsehood certain, or was in opposition to the writer's known prejudices and wishes, then we may accept the record as being as near certain truth as the nature of the case will allow.

Most historical testimony, however, itself rests on Tradition. testimony. Our aim is to get back to the record of the original observer; but this is very often impossible. Now, if the testimony is simply passed on through a chain of witnesses, fresh chances of error are introduced at each link, and each successive witness is of less worth than his predecessor; the longer the chain the weaker the evidence of the last link. This is the case with documents copied one from the other; each reproduces the errors of its predecessors, and probably introduces some new ones of its own. But this liability of error is enormously increased when the testimony is oral. It is a well-known parlour game, but one which well illustrates our point, to relate secretly a written story to the first of a ring of people, who similarly passes it on to the second, and so on, till the last tells the story aloud, or better still, writes it and reads it aloud. The comparison of this last version with the first

will be instructive to those who are disposed to accept all testimony given in good faith as certainly true.

When oral tradition passes on from generation to generation the variations become more marked ; yet it is in this legendary form that the earliest history of all peoples comes down to us. Quite evident is it that we are unjustified in accepting any such legends as true ; they may contain some truth, but it is certain they contain much error, and there are no means of sifting the true from the false. As Niebuhr says, a legend is "a mirage produced by an invisible object according to an unknown law of refraction."¹ Legends embody a people's ideas, but cannot be appealed to as records of facts.

Independent
Corrobor-
ation.

In other cases, however, the testimony of various witnesses support each other, either directly by recording the same fact independently, or by one set of witnesses testifying to the credibility of others. "In the acceptance of Livingstone's accounts of the countries through which he passed, are not the relevant grounds in part the esteem in which he was held by his contemporaries, coupled with their credentials ; in part the credentials of the societies and other media of record and publication through which his work has in successive stages come to the individual reader ? If I submit myself to the knife of the surgeon, how have I assured myself that he will do the right thing, unless by relying upon a complex tissue of testimony as to the professional ability of a large number of persons ?"²

Inference
from Ab-
sence of
Testimony.

§ 6.—One last point must be noticed, and that is the danger of inferring from mere absence of testimony to non-existence in fact. Even in the present, absence of observation does not prove absence of

¹ Quoted by Langlois and Seignobos, *op. cit.*, p. 182.

² Ravenshear, *op. cit.*, pp. 82—83.

existence. Every scientific discovery is, indeed, testimony to the contrary. Within the last few years, for instance, several gases whose existence had previously been unsuspected even by scientific experts, have been discovered in the atmosphere. A statement should be accepted on negative evidence only when the most careful precautions have been taken to secure the greatest possible completeness of that evidence. Darwin established on negative evidence that certain orchids secrete no nectar, but he only accepted the conclusion when he had observed the plants in question under every variety of circumstance that could affect the result.¹

Still more dangerous is it to infer that an event never occurred in the past because no record of it now remains. To render this probable we must have grounds for knowing that no such record ever did exist, and that the event would certainly have been recorded had it occurred. This much narrows the scope of the inference. When an author sets out to give a systematic account of a class of facts, we may assume that any fact of that kind which he does not mention did not exist, if that fact was such that it could not have escaped his notice had it existed, and must have been seen by him to be pertinent to his record. In all other cases we can only suspend judgment and confess our ignorance.

¹ Cf., Darwin, *Fertilization of Orchids*, pp. 38—39.

CHAPTER XIII

HYPOTHESES

Nature of
Hypotheses.

§ 1.—ALL reception of facts, whether by observation or from testimony, challenges the mind to fit them into a system by relating them to each other and to the totality of knowledge already possessed. The answer to this challenge is a hypothesis, or supposed relation suggested by the facts themselves. The likelihood of such a supposal being true is, of course, largely dependent on the knowledge of the mind that makes it. The savage assumes magic and supernatural agency where the scientist looks for natural causation. All attempts at the organization of facts into knowledge proceed, however, by way of hypothesis. Even simple recognition of an object is of the nature of hypothesis, though in most cases verification is immediate.¹ In ordinary life we are always making hypotheses. I go to catch a train, and I act on the hypothesis that the railway service is uninterrupted; I sit down to write this chapter guided by the supposition that my mind will follow a certain consecutive train of thought. These are hypotheses, for they are not

¹ Cf. pp. 146—147.

certainties. A fog or an accident may dislocate the railway service, and the state of one's health or some powerful disturbing circumstance may render consecutive thought impossible.

Every supposition, then, as to the relations of facts is a hypothesis, whether it is made in ordinary life or in science. But as scientific thought differs from other thought only in its greater precision, the nature and uses of hypotheses will be best studied in connexion with scientific examples. It may be said, indeed, that the special work of science is the testing and verification of hypotheses, for, as Herschel says, "We must never forget it is principles, not phenomena—the interpretation, not the mere knowledge of facts,—which are the objects of enquiry to the natural philosopher."¹

§ 2.—Hypotheses are suggested by facts, but they may be suggested in an indefinite number of ways. No rules can be given for forming them, and not every enquirer is equally prolific in hypotheses which turn out to be real "guesses at truth." Indeed, the great masters of science are marked above all else by an insight into the reasons of things at which the ordinary searcher after knowledge can only wonder. In this sense, a great scientist, like a poet, is "born, not made." "The inventor of hypotheses, if pressed to explain his method, must answer as did Zerah Colburn when asked for his mode of instantaneous calculation. When the poor boy had been bothered for some time in this manner, he cried out in a huff, 'God put it into my head, and I can't put it into yours.'"²

But knowledge also plays a part. A fact which means nothing to the unprepared mind may suggest

Origin of
Hypotheses.

¹ *Discourse on Natural Philosophy*, § 10.

² De Morgan, *Budget of Paradoxes*, p. 56.

a far-reaching hypothesis to the mind which is stored with appropriate knowledge and governed by an appropriate interest. Thus the common experiences of falling bodies and of the motions of the moon suggested to Newton the great theory of gravitation. Some discoveries, it is said, are made by accident; but such accidents only happen to those who are prepared to interpret them. Many crystals had been broken in the world before the accidental fracture of one suggested to the physicist Haüy the laws of crystallization.

As science advances, more and more discoveries are due to attempts to explain small deviations between observed facts and established laws. For example, the planet Uranus was observed to deviate from its calculated path, and to account for such deviations the hypothesis was formed that a hitherto unknown planet revolved round the sun at a still greater distance from it than Uranus. From the observed positions of Uranus the position of this supposed planet was calculated. Search with the telescope in that direction proved the accuracy of the hypothesis, and the new planet was named Neptune. In quite recent years an investigation suggested by a small unexplained difference between the weight of nitrogen obtained in the chemical laboratory and the gas which had hitherto been supposed to be pure nitrogen in the atmosphere, led to the discovery of argon. Many other instances could be given, but these are sufficient to show that in such cases not even the problem could suggest itself to a mind not conversant with the advances already made in the appropriate branch of knowledge.

Hypotheses
and Facts.

§ 3.—Hypotheses, then, are suggested by facts to the mind prepared to interpret them. It does not follow, however, that the greater the number of

facts, the more likely the hypothesis is to be right. The great difficulty always is to pick out the essential from the merely accidental in the whole mass of circumstances. Reality does not give us phenomena already sorted and selected, as the teacher of science presents them to his pupils in the class-room, and the main difference between the successful discoverer and the unsuccessful worker lies just in the power to see what may safely be neglected. But too great a wealth of facts increases this difficulty, for each new fact brings in some fresh attendant circumstances. This is very well put by Dr. Conan Doyle in the *Memoirs of Sherlock Holmes*. After Mr. Holmes had solved the problem of the *Naval Treaty* he says: "The principal difficulty . . . lay in the fact of there being too much evidence. What was vital was overlaid and hidden by what was irrelevant. Of all the facts which were presented to us, we had to pick out just those which we deemed to be essential, and then piece them together in their order, so as to reconstruct this very remarkable chain of events."

When, indeed, we can get what is called a "pure case," that is, an instance in which only those conditions are present which we are investigating, then we can immediately assert the relation from one instance, and that, not as a more or less probable hypothesis, but as a certain truth. In mathematics we can do this, for we entirely determine the operative conditions; our triangles, circles, &c., are ideal and perfect, and we infer their consequences from single cases. If, for example, we prove that one right-angled triangle is inscribable in a semi-circle, this proof depends only on the ideal nature of our figures, and is consequently applicable to every possible example in so far as it fulfils these

conditions. Thus our generalization is the immediate result of our construction.¹ But with concrete objects we cannot do this so thoroughly. In chemistry, it is to some extent possible. So long, for example, as the chemist means by 'water' nothing but absolutely pure water, what he finds true of one drop he can affirm to be true of every other drop. But the actual water in nature contains all kinds of impurities in very various amounts, and it is very difficult to get a pure case even here. It is, then, because nature only presents us with relations in "a tangle of many threads which science has to unravel"² that we must resort to hypotheses.

Danger of
Bias.

This resort, however, has its own dangers. Having guessed at an explanation, the mind naturally wishes to find it true, and thus there is the danger of bias in observing facts which bear on the hypothesis—the attitude of mind expressed by the saying, "if the facts do not agree with the theory, so much the worse for the facts." As Jevons truly says, "it is difficult to find persons who can with perfect fairness register facts for and against their own peculiar views."³

Nor is this the only danger. To infer the consequences of a hypothesis is generally a task of no great difficulty, whilst the careful testing and verification of a hypothesis by analysis of facts is laborious and often both difficult and tedious. There is, then, a temptation to be satisfied with the former process, and when this is yielded to, the result is the construction of elaborate systems of the universe out of all relation to fact. It is this tendency to substitute guess-work for real investigation, and imagination

¹ Cf. p. 132.

² Hobhouse, *The Theory of Knowledge*, p. 328.

³ *The Principles of Science*, p. 402.

for observation, which has made the ordinary 'practical man' so suspicious of what he calls 'theory,' and so fond of contrasting it with 'practice,' and of telling us that "an ounce of fact is worth a ton of theory." No doubt this is so if the 'fact' is true and the 'theory' false, but between true theory and real fact there is no opposition at all.

§ 4.—The formation of a hypothesis, then, must not be taken as the establishment of a truth. All hypotheses must be held subject to revision, to modification, even to rejection, should further knowledge of fact demand it. For though it is true that one single case is seldom sufficient to establish a hypothesis, it is equally true that one single fact which can be shown to be really in contradiction to a hypothesis overthrows it. Indeed, it is comparatively seldom that the first hypothesis suggested to the mind is the true one. Kepler records that he tried and rejected nineteen hypotheses before he hit on the laws of the motions of the planets round the sun. Similarly, in the discovery of argon two hypotheses were tried and rejected before the third one—that a hitherto unknown element exists in the atmosphere—was found to be verified by the facts.

Testing of
Hypotheses.

False hypotheses, as well as true ones, are suggested by analogies between the new facts and facts whose relations are already known. It is the extreme complexity of nature which makes a plurality of hypotheses possible. Sometimes several possible hypotheses occur to the mind at once, at other times they occur successively, and, it may be, at long intervals of time. But whenever they occur, scientific hypotheses are always grounded on some characteristic of the facts: they are never mere random guesses.

§ 5.—Because a hypothesis is finally rejected it

Descriptive
and Work-
ing Hypo-
theses.

does not, however, follow that it has been worthless in the advance of science. It may, in its time, have furnished a fairly accurate description of the perceived facts with which it dealt. "Although the Ptolemaic doctrine is now known to be framed on an utterly extravagant estimate of the true place of the earth in the scheme of the heavens, yet the apparent movements of the celestial bodies are accounted for by the theory with considerable accuracy."¹

Often a hypothesis is of a merely descriptive character, and is a more or less figurative way of expressing some abstract relation whose concrete terms are really unknown. It was, in this way, long customary to speak of the "electric fluid," though the existence of a material "fluid" was not implied, because the rapid and easy motion of a fluid was the nearest analogy to the known action of electricity. In a similar way many scientists for a long time regarded the atomic theory, which plays so large a part in modern chemistry, "as a kind of symbolism by which different chemical elements could be characterized, their compounds described, and the actual weights practically calculated. . . . Although . . . chemical research was governed all through the century by the atomic view of matter, it does not appear that philosophers considered the existence and usefulness of chemical formulæ as a proof of the physical existence of atoms, or of smallest indivisible particles of matter, in the older sense of the theory."²

Often hypotheses are put forward as mere *working hypotheses*, that is, guides to further enquiry. When a complex mass of phenomena is before us for analysis we must begin somewhere in our task of disentang-

¹ Ball, *Story of the Heavens*, p. 6.

² Merz, *History of European Thought in the Nineteenth Century*, vol. i., pp. 17—20.

ling its threads. Any hypothesis is better than none, so long as it fairly expresses the facts already examined. Hence, in every branch of science provisional hypotheses have guided investigation, though it was known that they did not exactly express the truth. "The theory of the two fluids in electricity did good service for a long time in enabling philosophers to define their ideas, to describe, calculate, and predict phenomena. In optics, the so-called corpuscular theory of light is still used with advantage as a convenient means of summarizing the laws of reflection and refraction."¹

§ 6.—Any hypothesis, then, is permissible which is sufficiently definite to allow its consequences to be deduced, and which is not inconsistent with itself or with any fully established law of nature. Even this last condition must be jealously scrutinized, for it has often happened that a new hypothesis has been true, though it was in conflict with what had previously been regarded as established knowledge. The Copernican theory that the daily motion of the heavenly bodies round the earth was only apparent, and in reality due to the daily rotation of the earth on its own axis, was in direct conflict with the Ptolemaic doctrine that the earth was absolutely fixed and immovable. But, as had, indeed, been seen by Ptolemy himself, the perceived facts could be explained on either hypothesis. The new theory, therefore, was not, so far, in real conflict with what was actually known, but only with an alternative way of explaining the known phenomena. Copernicus supported his view by showing that the Ptolemaic hypothesis "would attribute an almost infinite velocity to the stars, and that the rotation of the entire universe around the earth was really a prepos-

Permissible
Hypotheses.

¹ Merz, *op. cit.*, p. 422.

terous supposition.”¹ But when Copernicus took the second great step of denying to the earth that central position in the universe which for centuries had been assigned to it, a complete revolution in men’s systems of knowledge was demanded. Nor was this revolution confined to astronomy, for the belief that the earth was the centre of all things had naturally exercised a considerable influence upon man’s conception of his own importance, and these flattering ideas must now be considerably modified. Soon after the announcement of the Copernican hypothesis the invention of the telescope enabled men to enormously increase the number of facts which a true theory of the heavenly bodies must explain. It was the opposition between these facts and the Ptolemaic hypothesis, and their agreement with the Copernican hypothesis, which finally decided between these rival explanations.

Crucial
Instances.

§ 7.—So, in every case, it is fact alone which can decide between rival hypotheses. A fact which is thus decisive in that, at one and the same time, it disproves one hypothesis and confirms another, is called a *Crucial Instance*, and an experiment which exhibits such an instance is a *Crucial Experiment*. “Thus the phases of Venus, similar to those of the moon, but concurring with great changes of apparent size, when discovered by Galileo, presented a crucial instance in favour of the Copernican hypothesis, as against the Ptolemaic, so far at least as to prove that Venus revolved around the sun inside the orbit of the earth.”²

The history of science contains many beautiful examples of crucial instances and experiments. Some of the most interesting were experiments designed

¹ Ball, *The Story of the Heavens*, p. 7.

² Carveth Read, *Logic, Deductive and Inductive*, p. 217.

to decide between the two great rival theories as to the nature of light. According to Newton's corpuscular theory, luminous bodies actually emit exceedingly minute particles in all directions and at an enormous rate of speed. "A very different hypothesis had, however, been suggested about the same period by Huyghens, who supposed light to be produced in the same manner with sound, by the communication of a vibratory motion from the luminous body to a highly elastic fluid, which he imagined as filling all space, and as being less condensed within the limits of space occupied by matter, and that to a greater or less extent, according to the nature of the occupying substance. Thus, in place of anything actually thrown off, he substituted waves or vibrations, propagated in all directions from luminous bodies, through this medium, or ether, as he called it."¹ For a long time these rival hypotheses divided the scientific world, for each explained in a remarkable manner the known laws of reflection and refraction. To decide between them it was necessary to infer from the two hypotheses consequences contradictory to each other, and then to appeal to observation to show which of these agreed with fact. Now, "if the undulatory theory be true, light must move more slowly in a dense refracting medium than in a rarer one; but the Newtonian theory assumed that the attraction of the dense medium caused the particles of light to move more rapidly than in the rare medium. On this point, then, there was complete discrepancy between the theories, and observation was required to show which theory was to be preferred. Now, by simply cutting a uniform plate of glass into two pieces, and slightly inclining one piece so as to increase the length of the path of a ray passing

¹ Herschel, *Discourse on Natural Philosophy*, § 276.

through it, experimenters were able to show that light does move more slowly in glass than in air.”¹ Other crucial experiments also supported the undulatory theory and negatived the corpuscular, so that the former may now be regarded as completely established.

¹ Jevons, *The Principles of Science*, p. 521.

CHAPTER XIV

DIRECT DEVELOPMENT OF HYPOTHESES

§ 1.—All hypotheses, as we saw in the last chapter, are suggested by facts, but only to the mind prepared to interpret them. We must now examine the logical character of the inference involved in the formation and gradual development of hypotheses.

Accidental
Coin-
cidences
and
Necessary
Connexions

Every hypothesis is a suggested universal relation, for a scientific conception of the universe excludes all idea of mere casual occurrence. But though every fact can be ultimately accounted for by its relations, yet two or more facts may occur together, and so be related in time or space, without having any necessary connexion with each other. As

“ A raven cried ‘ Croak,’
And they all tumbled down.”

A suggestion that the falling was due to the croaking would be on quite as high a scientific level as are the beliefs in charms and magic which play so large a part in the lives of the superstitious. Such agreements in time of occurrence are merely accidental coincidences. By styling them ‘accidental’

no more is meant than that they have no necessary connexion with each other. One of the greatest difficulties of the search after knowledge is to distinguish between such coincidences and real connexion. It is the latter that is always suggested by a hypothesis, for only on the basis of necessary connexion can a universal relation be asserted. But even when an observed relation is really the expression of such a connexion, yet that relation may not always occur, for its expression in fact may be frustrated by the presence of other relations, themselves equally universal. Particular occurrences are all due to the combination and inter-action of universal relations which may support or hinder each other. Hence, the non-recurrence of a relation once observed is itself a fact to be accounted for by reference to other universal relations. In other words, the ground of a negation is equally universal with that of a positive relation.

Empirical
Generaliza-
tion and
Enumera-
tive In-
duction.

§ 2.—From the beginning of life the mind has a tendency to generalize its observations on very insufficient evidence. This merely means that there is at first no conception of the infinite complexity of reality and of the enormous number of conditions which may interfere to modify or hinder the expression in fact of a given relation. This tendency to generalize is both helped and guided by the use of language. Certain instances are observed to agree in possessing a particular attribute, or in acting in a certain way; and the direction in which this observed relation is generalized, and the extent to which that generalization is carried, are determined by the general idea, or concept, under which the observed instances are thought. For example, copper and iron are observed to expand when heated; and the mind tends immediately to generalize that

relation. But whether the generalization suggested is, that 'metals' expand when subjected to heat, or that 'solids' so expand, depends upon which of those general ideas occurs to the mind. So, in every case, what hypothesis is actually suggested is determined by the conception under which the instances are thought. Here comes in the first great difficulty in an inductive enquiry. All particular instances can be thought under an indefinitely large number of general ideas, some of which are represented in language by separate names, whilst others are not. Those so represented naturally occur first to the untrained mind, and those represented by nouns substantive first of all. But the idea covered by such words is always of a very concrete and complex character, whilst every relation is abstract, in that it is determined, not by the whole concrete nature implied by the name, but by some special element in that nature. A hypothesis, therefore, guided by a common noun will never explain the relation, and indeed will never even state it exactly; it only gives the first and most obvious result of a superficial observation. This step may be represented symbolically thus—

Instances a, b, c, d, agree in possessing P,
 But a, b, c, d, are instances of the class S;
 Therefore, S may be P.

Here it will be seen we have a syllogism in the third figure, with S undistributed in the premises. We are, therefore, not justified in drawing as our conclusion the definite statement that S is P, but only as suggesting such a universal relation as a hypothesis worthy of consideration.

Two kinds of evidence in support of this suggested universal are conceivable. The one which first

occurs to the untrained mind is to attempt to examine every case of S. This is what is meant by *Induction by Simple Enumeration*, of which Bacon truly said it "is a puerile thing, and concludes uncertainly, and is exposed to danger from any contradictory instance."¹ In all cases of the slightest importance it is evident that the examination of every instance is an impossibility. But even were it attainable the result would not be the establishment of a true universal relation. For it is only when a necessary connexion of content is shown that a relation can be affirmed as absolutely universal, and a mere summation of instances deals with nothing but their numerical aspect, and no ground of necessity can ever be found in simple counting.

Analogy.

§ 3.—We must, then, regard this step as only a first preliminary to the selection of a more exact and abstract general idea under which to think our instances. To find this we proceed to analyse them till we detect some element which seems to us a possible ground of the observed relation. This takes us to the form of argument known as *Analogy*, where the selected element naturally becomes the predicate in each of our premises and the inference falls into the second syllogistic figure—

P possesses the character M,
 These instances of S also possess the character M ;
 Therefore, these instances of S may be instances
 of P.

Again we see that no certain conclusion can be drawn, because our middle term is not distributed in either premise. Our conclusion is still, then, only a hypothesis, but it is a hypothesis having a greater probability than at the end of the first step, because

¹ *Novum Organum*, bk. i., § 105.

we have in M a suggested ground of the observed relation. The hypothesis would now be most completely expressed by "M may be the ground of the relation of S and P," or by the equivalent hypothetical form "If S is M it may be P."

It is evident that the whole value of such a hypothesis depends upon whether M is really important to the suggested relation between S and P. Directly we can prove that M is actually the ground of this relation, our argument ceases to be analogical and becomes demonstrative, our conclusion passes from a supposition or hypothesis into an established truth. The process of such proof must be examined later; we are now concerned to emphasize the point that the value of an analogical argument, that is, the degree of probability attaching to its conclusion, depends entirely on the importance of the selected middle term M.

All analogy is argument from resemblance; from observing a certain quality in things of a particular kind we infer that the same quality will be possessed by other things of that kind. Such inferences are of very various degrees of worth, proportioned to the importance of the resemblance on which they are based. And what is important from one point of view is unimportant from another; resemblances from which we might plausibly infer athletic prowess might only mislead if our inference were to intellectual ability. Nor are the resemblances which first attract notice necessarily the most important for our purpose. The resemblances between sponges and marine plants are obvious, and yet an inference to the nature of sponges based on that resemblance would be entirely wrong. We frequently hear the argument that a nation is like a man, subject to periods of growth, maturity, and decay, in necessary

sequence on each other, and the conclusion is regarded as certain. Now, no conclusion from mere analogy, as we have seen, can be certain, but in this particular case it is doubtful if it is even of any great strength. As Burke well put it: "I am not quite of the mind of those speculators who seem assured that necessarily, and by the constitution of things, all states have the same periods of infancy, manhood, and decrepitude, that are found in the individuals who compose them. Parallels of this sort rather furnish similitudes to illustrate or to adorn, than supply analogies from whence to reason. The objects which are attempted to be forced into an analogy are not found in the same classes of existence. Individuals are physical beings subject to laws universal and invariable. The immediate cause acting in these laws may be obscure: the general results are subjects of certain calculation. But commonwealths are not physical but moral essences. They are artificial combinations, and, in their proximate efficient cause, the arbitrary productions of the human mind. We are not yet acquainted with the laws which necessarily influence the stability of that kind of work made by that kind of agent."¹

Nor should very considerable differences in outward appearance lead to the assumption that there is no hidden, but essential, identity. Dr. Wallace gives a most striking instance, in which not only the common observer but even the very elect of botanical specialists had for long been misled by such differences. "All the cucumbers and gourds vary immensely, but the melon (*Cucumis melo*) exceeds them all. A French botanist, M. Naudin, devoted six years to their study. He found that previous

¹ *Letters on a Regicide Peace*, Works, vol. viii., pp. 78—79.

botanists had described thirty distinct species, as they thought, which were really only varieties of melons. They differ chiefly in their fruits, but also very much in foliage and mode of growth. Some melons are only as large as small plums, others weigh as much as sixty-six pounds. One variety has a scarlet fruit. Another is not more than an inch in diameter, but sometimes more than a yard in length, twisting about in all directions like a serpent. Some melons are exactly like cucumbers; and an Algerian variety, when ripe, cracks and falls to pieces, just as occurs in a wild gourd.”¹

Such an example brings out clearly that the strength of an analogy cannot be calculated from the amounts of outward resemblance and difference between the cases, because the resemblance really important for the purpose in view may be a hidden one. This shows why it is that full and appropriate knowledge bears such an important part in the framing of hypotheses worthy of investigation. Were the strength of the analogy dependent only on the amount of outward likeness, the framing of fruitful hypotheses would require mainly a pair of good eyes, and the work of induction would be something very different from the task of enormous difficulty and complexity it really is. It is because the grounds of the relations we observe are not only hidden, but often even disguised, that the advance of knowledge is slow, even though the greatest of human intellects are engaged in helping it forwards.

Of course, when knowledge is not sufficiently advanced to determine the relative importance of points of resemblance and difference, it is necessary to work with the material at hand. For example, in the early stages of electrical science, “Franklin

¹ *Darwinism*, pp. 87—88.

enumerates specifically an agreement between electricity and lightning in the following respects :— Giving light ; colour of the light ; crooked direction ; swift motion ; being conducted by metals ; noise in exploding ; conductivity in water and ice ; rending imperfect conductors ; destroying animals ; melting metals ; fring inflammable substances ; sulphureous smell (due to *ozone*, as we now know) ; and he had previously found that needles could be magnetized both by lightning and by the electric spark. He also drew attention to the similarity between the pale blue flame seen during thundery weather playing at the tips of the masts of ships (called by sailors St. Elmo's Fire), and the 'glow' discharge at points."¹ Here some of the resemblances are magnetic, and therefore, important, but others, such as the colour and smell, did not, by themselves, lend much support to the hypothesis of identity of nature between lightning and electricity. With the advance of any science the hypotheses suggested in it tend to become continually more probable, because the increase of knowledge enables a clearer distinction to be drawn between the weakness and strength of the analogies on which they are based.

Nature of
Direct
Methods in
Induction.

§ 4.—A hypothesis having been suggested by analogy it must be brought to the test of fact for confirmation or denial. But no hypothesis must be regarded as a fixed and unchangeable formula. Though it may be on the whole supported by further observations, yet it frequently undergoes many modifications before it attains the form in which it is finally accepted. The aim is to analyse the concrete and complex facts of experience so as to disentangle the universal and abstract relations which are com-

¹ S. Thompson, *Elementary Lessons on Electricity and Magnetism*, 2nd Edition, p. 254.

bined in them. Every such relation is always overlaid with all kinds of attendant circumstances, some of which are indifferent to it whilst others are not. The task of induction is to separate from all this irrelevant mass of material the relation expressed by the hypothesis which guides the enquiry, so as to find what it is in itself, independently of all interfering conditions.

When the hypothesis deals with a simple causal sequence, the whole of which is open to observation, this task can be to some extent carried out directly by certain inductive methods which were first clearly formulated by Mill, as the results of his analysis of the methods of enquiry in physical science set forth by Herschel in his *Discourse on Natural Philosophy*. These methods can deal only with phenomena directly perceptible by the senses, and, hence, cannot reach those more hidden laws which express the most fundamental relations. As Dr. Venn says: "It is very important that the student should clearly recognize that these Inductive Methods, which play so important a part in our logical treatises, are not of a rigidly scientific character. They belong rather to what may be called the plane or level of popular enquiry. . . . These Methods are nothing more than practical applications of the Law of Causation when this is interpreted in a popular scientific form."¹ But this does not destroy their practical utility. In all the ordinary affairs of life we are content with even less confirmation than these methods can supply, and in science itself they play an important part in the suggesting, testing, and moulding of hypotheses.

As applications of a view of causation, half scientific and half popular, the methods assume that every

¹ *Empirical Logic*, p. 420.

event has a cause, that the same cause always tends to produce the same effect, and that the effect is equal in energy to the cause. But as the only causes they deal with are those open to sense-perception they cannot assume that the same effect is always due to the same cause, for as we have seen, this identity of the causal relation is often found only when we get behind sense-perception to the hidden reality which the perceived facts more or less adequately express.¹

With these limitations the methods all aim at eliminating from the concrete facts all elements which are indifferent to the relation under investigation. Their fundamental principle is that whatever cannot be removed without altering the observed phenomenon is a condition of its occurrence, and whatever can be so withdrawn is in no essential connexion with it. As corollaries from this, and special expressions of the axiom of the equality of cause and effect in energy, are the more special principles that elements which show corresponding variations in amount or intensity are causally connected, whilst if the increase or decrease of the one is not attended by a similar variation in the other they do not form a causal sequence; and that any difference in amount between phenomena regarded as cause and effect presents a further problem for investigation.

These principles may be expressed symbolically by the formulæ $AB \rightarrow xy$; $AC \rightarrow xz$, where any of the letters may represent a whole complex of elements. Then, as B can be removed without affecting x , it is assumed that $B \rightarrow x$ is not a causal sequence, whilst as the removal of B is attended by the disappearance of y , it is inferred that B and y are causally connected. The inference involved may be

¹ *Cf.*, p. 36.

expressed in two syllogisms ultimately resting upon the second axiom of causation, thus—

Any cause is always followed by the same effect,

A is followed in this case by x and y ; (*1st formula*)

Therefore A is always followed by either x or y.

Then, taking this conclusion as a premise—

A is always followed by either x or y,

But A is not always followed by y ; (*2nd formula*)

Therefore A is always followed by x.

This brings out the fact that the whole argument becomes precise and definite only by the use of the negative instance which excludes A—y as a causal sequence. The validity of the whole inference evidently depends upon the truth and sufficiency of the actual premises which are here represented symbolically. The use of such symbols, however, disguises the greatest difficulty of the whole process, for we cannot get to any premises which may be fairly represented by them till we have done much of the work of induction. Nature does not present us with definite sets of distinct elements standing in known relations to each other. We, therefore, do not start with anything corresponding to the symbolic formulæ ; but rather, the filling up of those formulæ is the result of analysing a process already more or less completed. But though this is true, yet the purpose of so arranging the facts as to fulfil the conditions of the formulæ is operative throughout, and the actual process consists in a gradual approximation to such definite arrangement.

Lastly, it must be remembered that though for the sake of clearness in exposition, the inductive methods will be treated separately, yet in any full inductive enquiry they are used together in any combination, and, as the symbolic statement shows, they are all expressions of one fundamental principle.

Method of
Agreement.

§ 5.—We have seen that simple enumeration of instances in which certain phenomena occur together or in immediate succession to each other suggests a hypothesis of necessary connexion. The *Method of Agreement* attempts to confirm this hypothesis by varying, as much as possible, the circumstances in which the relation is observed, so that all indifferent concomitants may be eliminated. If only one element is found constant under whatever conditions the phenomenon occurs that element is inferred to be probably the cause of the phenomenon. This is symbolized by the $A-x$ of our formulæ. For example, solids become liquids, and liquids change into gases, under all kinds of varying conditions, but one element, the presence of heat, is common to many of them. The inference is that heat is probably the cause of the change. Of course the evidence thus gathered is only sufficient to suggest this as a probable hypothesis ; a knowledge of the molecular structure of matter and of the action of both heat and pressure on molecular motion is necessary really to explain the phenomena, and this cannot be attained by any of the methods of direct induction we are now considering.

The same limitation of the operation of the method is seen in an excellent example which we borrow from Professor Bain. “The north-east wind is known to be specially injurious to a great many persons. Let the enquiry be—what circumstances or quality is this owing to? By a mental analysis, we can distinguish various qualities in winds ;—the degree of violence, the temperature, the humidity or dryness, the electricity, and the ozone. We then refer to the actual instances to see if some one mode of any of these qualities uniformly accompanies this particular wind. Now we find, that as regards *violence*, easterly winds are

generally feeble and steady, but on particular occasions, they are stormy; hence, we cannot attribute their noxiousness to the intensity of the current. Again, while often *cold*, they are sometimes comparatively warm; and although they are more disagreeable when cold, yet they do not lose their character by being raised in temperature; so that the bad feature is not coldness. Neither is there one uniform degree of *moisture*; they are sometimes wet and sometimes dry. Again, as to *electricity*, there is no constant electric charge connected with them, either positive or negative, feeble or intense; the electric tension of the atmosphere generally rises as the temperature falls. Farther, as regards *ozone*, they have undoubtedly less of this element than the south-west winds; yet an easterly wind at the seashore has more ozone than a westerly wind in the heart of a town. It would thus appear that the depressing effect cannot be assigned to any one of these five circumstances. When, however, we investigate closely the conditions of the north-easterly current, we find that it blows from the pole towards the equator, and is for several thousand miles *close upon the surface of the ground*; whereas the south-west wind coming from the equator descends upon us from a height. Now, in the course of this long contact with the ground, a great number of impure elements—gaseous effluvia, fine dust, microscopic germs—may be caught up and may remain suspended in the lower stratum breathed by us. On this point alone, so far as we can at present discover, the agreement is constant and uniform.”¹ Here, it will be seen, Dr. Bain passes beyond the simple Method of Agreement both in appealing to the negative and contrasted instance of the south-west wind, and in the

¹ *Logic*, vol. ii., p. 53.

explanation of why passing near the ground should make a wind injurious.

The Method of Agreement, then, can give us no more than an indication of the direction in which it would be well to push our enquiries. The degree of probability which we can attribute to the suggested hypothesis will depend upon the thoroughness with which all possible combinations of circumstances have been observed. It is in this variation of conditions that increase in the number of examples has value. Fifty examples of a sequence under the same conditions are of no more value than one, supposing that to have been correctly observed. But as we vary the instances we decrease the likelihood that the phenomenon can have more than one 'cause,' using the term in the half popular sense in which the methods employ it.

But even invariable coincidence will not prove a causal relation. Day always follows night, and night succeeds to day, yet neither is the cause of the other. Both are joint effects of a deeper cause which the Method of Agreement cannot reach. Again, the invariable element may be a permanent fact in the universe, and in no causal relation to the phenomenon in question. As Mr. Hobhouse remarks: "Wherever there is sea we find sky; but we do not make sea the cause of sky, because we do not find the sky coming into being when or where the sea appears. Conversely, fire is the cause of smoke, because the smoke comes out of the fire and disappears as the combustion ceases."¹

This leads us to see that without negative instances the inductive enquiry cannot advance either very far or very surely. The inference that increase of heat causes the change of solids into liquids and of liquids

¹ *The Theory of Knowledge*, p. 367.

into gases, gains in probability when it is shown that decrease of heat has the opposite effect ; and, as we saw, Dr. Bain finds in the negative instance of the south-west wind a confirmation of his hypothesis as to the reason of the noxiousness of the north-east wind.

§ 6.—The Method of Agreement, then, must pass into the *Method of Exclusions*—or the *Joint Method of Agreement and Difference*, as Mill not very happily called it. Here the observation of positive instances is supplemented by the search for other instances, resembling the former as much as possible, with the one exception of the absence of both the supposed cause and effect. We constantly make inferences on the basis of this method in common life. “If a man finds that whenever he eats cucumber he suffers from indigestion, this indicates by Agreement that cucumber is the cause of his pain. But, if he is fond of cucumber, he will put the fault upon other ingredients of his diet taken at the same time, such as cheese, salmon, or pastry, which he likes less. Making, however, a second list of dinners (say) when visiting, at which cucumber is not served, whilst cheese, salmon, pastry, &c., all occur, and finding that he does *not* suffer from indigestion, the conclusion seems to be forced upon him that cucumber is the only pleasure of the table that must be bought with pain.”¹

Method of
Exclusions.

It was mainly by this method that Darwin established his theory that vegetable mould is due to the action of earth-worms. He found that on lands of various kinds a layer of vegetable mould, continually increasing in thickness, is formed whenever earth-worms are present in any considerable numbers, so that objects left on the surface gradually become

¹ Carveth Read, *Logic, Deductive and Inductive*, p. 178.

buried. On the other hand, where worms are practically absent, this phenomenon does not appear. Darwin used the method very thoroughly, and showed that what at first sight appeared to be exceptions were really negative instances. Large boulders were not buried, but investigation showed that under such boulders no earth-worms were to be found.

It appears from such examples that the negative instances are even more decisive than the positive, for they clear the ground of other possible alternative causes.

Method of
Difference.

§ 7.—An attempt to render the negative instance as precise as possible is made by the *Method of Difference*. The methods already considered have been methods of observation, but this is pre-eminently a method of experiment. Its aim is to vary, one at a time, the circumstances under which a phenomenon occurs. If, then, the supposed effect is found to appear and disappear with the introduction and withdrawal of the supposed cause, the assumption of causal connexion is a strong one. The method is symbolized by the B—y and C—z of our formulæ.

It is obvious, however, that the method is emphatically one of testing and verification rather than of discovery; for unless we suspect a certain element to be the cause, why do we experiment with that rather than with any other of the concrete conditions?

It is very rarely that nature gives to observation such a perfect negative instance as the Method of Difference requires, and even in experiment it is extremely difficult to secure one. The surest plan is to introduce one new factor into a definitely known set of conditions. For example, as was accidentally

discovered by Boyle in 1670, if an acid is introduced into an extract of litmus the colour is changed from blue to red, and the inference that the change is due to the acid is felt to be so safe that this change is the recognized test for the presence of an acid. But when, in experiment, we do attempt to make one definite change, it is often excessively difficult to avoid introducing at the same time other changes which are not intended and which may not even be suspected. Dr. Venn gives a very instructive instance from the Report of the British Association, 1881. "When Prof. G. H. Darwin and his brother were endeavouring to measure the lunar disturbance of gravity at the Cavendish Laboratory an extremely delicate pendulum was employed. So delicate was it that it almost defeated its purpose by registering innumerable minute disturbances, of which, whilst many could be accounted for, many others baffled all explanation. Amongst the former was this. In approaching the instrument in order to observe its reading, the surface level of the stone basement floor on which the instrument stood was deflected by the weight of the observer. Nay, as he stood to take a reading, the difference produced in this way by his merely shifting his weight from one leg to the other was perceptible; so it became necessary always to observe the reading by a telescope from a distance, or to adopt some equivalent plan."¹ As Dr. Venn goes on to observe, "Now of course exactly the same sort of disturbance is brought about whenever we have a letter weighed at the Post Office. But as it is not considered that the extra pence at stake are worth the trouble of deciding the weight of the letter to such a point of accuracy, we are content to let this source of inaccuracy enter, and therefore we use

¹ *Empirical Logic*, pp. 417—418.

instruments too coarse to indicate it when it does enter.”¹ Such an example shows how difficult, if not impossible, it is to secure that only one circumstance is really varied at a time.

Even supposing this difficulty overcome there still remains the probability that the new element introduced is not by itself the cause of the result. A lighted match is applied to a heap of gunpowder and an explosion follows, but the match by itself is not the cause of that explosion. And so it is generally. All that the Method of Difference can prove is that the introduction of a certain new element into a definite set of conditions is essential to the production of the effect in that case. But the cause may even lie wholly in some of the previous conditions, though held in check by others of those conditions, and all that the new element may do is to neutralize those interfering conditions and allow the causal connexion to have full play. For example, if the string which supports a picture breaks, the interference with the causal action of gravity is removed, but only in the most popular sense of the term can the breaking of the string be called the cause of the fall of the picture. The Method of Difference alone will not, therefore, establish a pure case of causal connexion between the introduced element and the result. But when other evidence points to such a connexion, the confirmation afforded by this method is very strong, and in cases of ordinary experience, where scientific accuracy is not required, it may often be regarded as practically conclusive. Such cases are the most numerous in the affairs of every-day life. “Many precautions, for instance, which it would be ridiculous for a tradesman to adopt if he were weighing out a pound of sugar for a customer,

¹ *Empirical Logic*, pp. 417—418.

are just the things which it would be little short of criminal for an analytical chemist *not* to adopt, if he were set to determine whether a given sample of water were pure. And precautions again which would suffice for this latter may again become insufficient when some original investigator is carrying out an excessively refined course of experiments in his laboratory. All accuracy in these matters is a question of degree, to be determined by the end we have in view, and strictly regulated by the necessities which the attainment of that end reasonably demands.”¹

§ 8.—The evidence of causal connexion furnished by a combination of affirmative and negative instances is considerably strengthened when the facts can be brought under the *Method of Concomitant Variations*, the principle of which is that corresponding changes in the amount of phenomena give a presumption of causal connexion. By itself such variation is strong evidence of causal connexion only when the amount of the supposed cause can be changed at will and when the assumed effect varies in simple proportion with it. But if the supposed cause is not under control, so that the variations can only be observed, and not determined, by us, then there is always the possibility that both the observed phenomena may be joint effects of an unknown cause. On the other hand, if the variations of the assumed cause and effect follow different laws it is evident that the full cause is not known. If, for example, in the sequence $A \rightarrow x$, we have as variations A , $2A$, $3A$, &c., and x , $4x$, $9x$, &c., then it would seem certain that A cannot be the whole cause of x . When the variations cannot be

Method of
Concomi-
tant
Variations.

¹ Venn, *op. cit.* p. 417.

measured, so that we can only observe that some change in x is connected with every change in A , the evidence is, of course, considerably weaker than when measurement is possible. It appears, then, that the mere fact of concomitant variation cannot, by itself, prove causal connexion. But when it is used to supplement the Method of Exclusions or that of Difference it considerably strengthens the evidence, even when measurement is impossible.

To take an example from biology. Darwin advanced the hypothesis that flowers "have been rendered conspicuous in contrast with the green leaves, and in consequence at the same time beautiful, so that they may be easily observed by insects. I have come to this conclusion from finding it an invariable rule that when a flower is fertilized by the wind it never has a gaily-coloured corolla. Several plants habitually produce two kinds of flowers: one kind open and coloured so as to attract insects; the other closed, not coloured, destitute of nectar, and never visited by insects."¹ Here we have a hypothesis suggested by the Method of Exclusions. Further observations directed to the testing of this hypothesis have shown that the Method of Concomitant Variations is applicable. Thus Dr. Wallace writes: "The argument in favour of this view is now much stronger than when [Darwin] wrote; for not only have we reason to believe that most of these wind-fertilized flowers are degraded forms of flowers which have once been insect-fertilized, but we have abundant evidence that whenever insect agency becomes comparatively ineffective, the colours of the flowers become less bright, their size and beauty diminish, till they are

¹ *The Origin of Species*, p. 161.

reduced to such small, greenish, inconspicuous flowers as those of the rupture-wort . . . the knotgrass . . . or the cleistogamic flowers of the violet.”¹

Mr. Hobhouse gives an instructive example of a similar strengthening of the Method of Exclusions by that of Concomitant Variations. “Wealth is greatly increased by the change from production on the small to production on a large scale, by the introduction of machinery and the division of labour. This holds equally if we compare a railway with a stage-coach, or a coach with a pack-horse; a cotton-mill with a spinning-wheel, or a spinning-wheel with a distaff and spindle. Under every form, at every stage and in every period, wealth has been increased by improved and extended co-operation between human beings. This complex co-operation of many-sided individual effort then appears as the main-spring of industrial progress. Where it is not we have stagnation—primitive barbarism; where it is found, in whatever form or degree, there by one means and another industry is improved and the material side of life made perfect.”²

Especially valuable is the Method of Concomitant Variations when a really negative instance cannot be obtained, because the cause is a permanent factor throughout the universe. We cannot, for instance, get rid of either gravitation or temperature. But the latter can be varied at will between comparatively wide limits and the effect of this variation on different phenomena noted, whilst even with the former such experimental variation is not out of the question. By ascending a high mountain or going up in a balloon, experiments can be made on the rate at which a body falls towards the earth, and by

¹ *Darwinism*, p. 332.

² *The Theory of Knowledge*, p. 370.

careful measurements this rate can be shown to decrease, continuously though gradually, as the height above the level of the sea increases.

Such examples of the Method of Concomitant Variations show that in its most perfect application it becomes a method of establishing relations in a quantitative form. None of the other methods can determine quantitative relation between cause and effect, yet without such determination the statement of relations remains vague and indefinite. As Herschel says: "Numerical precision . . . is the very soul of science . . . Indeed, it is a character of all the higher laws of nature to assume the forms of precise *quantitative* statement."¹ No doubt, measurement is never exact, though it becomes more so with the improvement of instruments. But by dealing with a series of measurements by averaging and other methods of statistics, a law is calculated which is more correct than any actual measurements. "The place of a planet at a given time is calculated by the law of gravitation; if it is half a second wrong, the fault is in the instrument, the observer, the clock, or the law; now, the more observations are made, the more of this fault is brought home to the instrument, the observer, and the clock."²

The form of the quantitative variation between two elements is often most clearly seen when it is represented graphically, as in the diagrams of the variations of the heights of the barometer and thermometer common in newspapers. A horizontal line, called the abscissa, represents the units of one element, and a perpendicular line, termed the ordinate, those of the other. "If the abscissæ represent intervals of time, and the ordinates correspond-

¹ *Discourse on Natural Philosophy*, §§ 115—116.

² Clifford, *Lectures and Essays*, pp. 91—92.

ing heights of the barometer, we may construct curves which show at a glance the dependence of barometric pressure upon the time of day.”¹ Curves constructed on the same principle are extremely valuable for exhibiting the variations in the growth of children with their age. The abscissæ show the age divided into years or other convenient units of time, the ordinates, the various physical measurements, such as height, weight, and chest-girth. Tables thus constructed and showing the average of a large number of measurements make evident, for example, that, as compared with the average development of English children, the Lancashire half-timers show an arrest of development coincident in time with their beginning to work in the cotton-mills.²

When the Method of Concomitant Variations suggests a hypothesis, care must be taken to determine the limits within which it is really applicable, by finding the negative instances which mark those limits. For example: “Water contracts as it is cooling. Suppose we begin to note this continued contracting of water from 100° F. to 90° ; we naturally expect to find it continuing through 90° to 80° . And as we observe, we find our expectations confirmed. And so on through to 40° , we find that water continues to contract. It is, therefore, most natural for us to expect to find water contracting at 39° . But just at this point in the series, there is a break in the continuity of variation; at 39° water begins to expand and so continues until it passes into the solid form at the freezing point.”³

¹ Thomson and Tait, *Elements of Natural Philosophy*, vol. i., p. 119.

² See the Tables given in Mr. Mark's *Educational Theories in England*, pp. 52—53.

³ Hibben, *Inductive Logic*, pp. 142—143.

Method of
Residues.

§ 9.—Mill enunciated a fifth method, that of *Residues*, whose principle is that when the known causes at work are not sufficient to account for the whole of the observed effect, the residual phenomenon presents a further problem for investigation. This is only a method by which hypotheses are suggested, and, as several instances of its working have already been mentioned, we need not consider it further.¹

Example of
use of
Methods—
Colour of
Animals.

§ 10.—We will close this chapter by illustrating the employment of the various inductive methods in one and the same scientific enquiry, choosing as our example Dr. Wallace's account of the investigation into the origin of modifications of colour in animals. The existence of a problem is suggested not by mere variation of colour, which "would require no other explanation than does that of the sky or the ocean, of the ruby or the emerald—that is, it would require a purely physical explanation only."² It is "the fact that the colours are localized in different patterns, sometimes in accordance with structural characters, sometimes altogether independent of them; while often differing in the most striking and fantastic manner in allied species," which compels us "to look upon colour not merely as a physical but also as a biological characteristic."³ So far we have simple enumeration. Then the Method of Exclusions is employed to suggest a hypothesis. "As a rule, colour and marking are constant in each species of wild animal, while, in almost every domesticated animal, there arises great variability."⁴ Then analogy is appealed to for a common characteristic, present uniformly in the one case and absent in the other, which may give the ground of this uniformity. "The essential difference between the conditions of life of

¹ See p. 168.

² *Darwinism*, p. 189.

³ *Ibid.*

⁴ *Ibid.*, p. 189—190.

domesticated and wild animals is, that the former are protected by man, while the latter have to protect themselves."¹ Hence arises the hypothesis that the variations of colour in wild animals is of use to them in the maintenance of life.

On proceeding to test this hypothesis, "the fact that first strikes us in our examination of the colours of animals as a whole, is the close relation that exists between these colours and the general environment. Thus, white prevails among arctic animals ; yellow or brown in desert species ; while green is only a tropical colour in tropical evergreen forests."² Here the Method of Agreement suggests that the colour of the animals is related to that of their surroundings.

Dr. Wallace then examines the case of arctic animals in more detail, and is able to appeal to the Method of Concomitant Variations in addition to that of Agreement. "In the arctic regions there are a number of animals which are wholly white all the year round, or which only turn white in winter. Among the former are the polar bear and the American polar hare, the snowy owl and the Greenland falcon ; among the latter the arctic fox, the arctic hare, the ermine, and the ptarmigan. Those which are permanently white remain among the snow nearly all the year round, while those which change their colour inhabit regions which are free from snow in summer."³ This supports the hypothesis that the colouring is "protective, serving to conceal the herbivorous species from their enemies, and enabling carnivorous animals to approach their prey unperceived."⁴

This, however, is not the only possible hypothesis. "Two other explanations have . . . been suggested. One is, that the prevalent white of the arctic regions

¹ *Darwinism*, p. 190.

² *Ibid.*

³ *Ibid.*

⁴ *Ibid.*

has a direct effect in producing the white colour in animals, either by some photographic or chemical action on the skin or by a reflex action through vision. The other is, that the white colour is chiefly beneficial as a means of checking radiation and so preserving animal heat during the severity of an arctic winter. The first is part of the general theory that colour is the effect of coloured light on the objects—a pure hypothesis which has, I believe, no facts whatever to support it. The second suggestion is also an hypothesis merely, since it has not been proved by experiment that a white colour, *per se*, independently of the fur or feathers which is so coloured, has any effect whatever in checking the radiation of low-grade heat like that of the animal body. But both alike are sufficiently disproved by the interesting exceptions to the rule of white coloration in the arctic regions, which exceptions are, nevertheless, quite in harmony with the theory of protection.”¹

These exceptions are, then, crucial instances which decide between the rival hypotheses. Dr. Wallace examines several in detail and shows they are either not really exceptions to the rule of protective coloration or that the animals have no need of such protection. “The sable retains its rich brown fur throughout the Siberian winter ; but it frequents trees at that season and not only feeds partially on fruits or seeds, but is able to catch birds among the branches of the fir-trees, with the bark of which its colour assimilates.”²

The musk sheep is also brown, “but this animal is gregarious, and its safety depends on its association in small herds. It is, therefore, of more importance for it to be able to recognize its kind at

¹ *Darwinism*, pp. 190—191.

² *Ibid.*, p. 191.

a distance than to be concealed from its enemies . . . But the most striking example is that of the common raven, which is a true arctic bird, and is found even in mid-winter as far north as any known bird or mammal. Yet it always retains its black coat, and the reason, from our point of view, is obvious. The raven is a powerful bird and fears no enemy, while, being a carrion-feeder, it has no need for concealment in order to approach its prey."¹ These apparent exceptions are, therefore, brought under the Method of Exclusions and shown to be really negative instances. It is only when this can be done that "exceptions prove the rule."

Dr. Wallace then proceeds to show that the same principle applies throughout animal life. "In the desert regions of the earth we find an even more general accordance of colour with surroundings. . . . Passing on to the tropical regions, it is among their evergreen forests alone that we find whole groups of birds whose ground colour is green."² Nocturnal animals, fish, eggs, all furnish additional examples, and, in every case, apparent exceptions can be shown to be either not exceptions at all as their colour is adapted to their individual environment, or else to be really negative instances generally coming under the head of colour for recognition in the case of gregarious animals.

Even such a brief and condensed outline as this of a piece of real scientific work will show the extreme difficulty of the task, the care with which every apparent exception must be investigated, and the importance for corroboration of negative instances.

¹ *Darwinism*, p. 191.

² *Ibid.*, p. 192.

CHAPTER XV

INDIRECT VERIFICATION OF HYPOTHESES

Relation
of Indirect
to Direct
Methods.

§ 1.—The methods of direct inductive enquiry which we considered in the last chapter are only applicable to simple cases in which the whole of the supposed causal sequence can be observed, and even in such cases they only form the first steps in an inductive enquiry. Their results are what are commonly called *Empirical Laws*, that is, laws of a descriptive character giving the results of sense-perception. They may state that an observed sequence is most likely causal, but they give no reason why it is so, for each law stands as an isolated fact, and is, therefore, unexplained. Such laws can never attain theoretical certainty, though they may have a high degree of probability. Certainty is only reached when we are able to show “not merely that that particular supposition will explain the facts, but also that no other one will.”¹ In other words, we must exclude the possibility of alternative causes. But, as has been seen, this cannot be done so long as we keep to sequences open to sense-perception, for the causal relation is

¹ Clifford, *Lectures and Essays*, p. 137.

often a hidden one. Even when we can use the inductive methods, therefore, we must still supplement them if we wish to attain to scientific precision and certainty. The only way to do this is to assume a hypothesis as to the hidden cause, to deductively infer the consequences of that hypothesis, and to compare those consequences with fact.

Such a hypothesis is still suggested by facts under the guidance of analogy, but it does not, as it were, lie on the face of the facts, and the suggestion is not a direct one. The facts have been already brought under empirical laws of considerable probability before the attempt is made to organize those laws under wider and more certain generalizations. The empirical laws form the immediate material from which this deeper induction starts. It is obvious that in this higher work of science we have a task of infinitely greater difficulty, and requiring immeasurably greater knowledge, than any we have yet considered. The establishment of every such hypothesis marks indeed an epoch in the advance of knowledge. As examples, we may cite the theories of Gravitation and of Evolution, which revolutionized the physical and biological sciences.

§ 2.—It is not, however, only in these higher realms of knowledge that the indirect method is the only one available, and we shall first consider it in simpler cases. Whenever the whole causal sequence is not open to inspection, we are compelled to resort to it. If we are given an effect and have to find its cause, the only method available is to assume a cause hypothetically, deduce its consequences, and see if they agree with the facts. A single real exception is fatal, but, as we saw in the last chapter, many facts which at first sight seem to be exceptions, turn out upon deeper investigation to be really

Initial Use
of Indirect
Method.

negative instances by which the hypothesis is confirmed.

Circum-
stantial
Evidence.

In the ordinary affairs of life we are contented with hypotheses which fairly cover the facts, without demanding proof that they do so exactly, or that no other supposition will do so. We cannot wait in practice for theoretical certainty. Even in the law-courts, if the facts adduced make strongly against an accused person, the prisoner must either establish other facts incompatible with his guilt, or take the consequences. Especially is this so in cases of 'circumstantial evidence,' in which the concurrence of many facts, each in itself perhaps of no great importance, often gives a presumption of very strong probability in favour of a certain hypothesis. As Mr. Hobhouse says: "A man is found dead with his throat cut. A knife is found in a ditch close by. There are footprints in the mud. X was known to be in the neighbourhood on the day; evidence is given that he purchased the knife a week before; his boots fit the footprints. All these facts might be due to a collocation of separate causes, but all are explicable by a single cause, namely, that X planned and carried out the murder. The single assumption is so much more probable than the multiple combination of circumstances that it is likely to go hard with X, and his business is to produce some fact incompatible with the above explanation. Failing this, one or two more such combinations of circumstances and our conviction of the strength of the hypothetical argument will be evinced in a very practical manner.'¹ But, even at the best, the conclusion is only a probable one, and, undoubtedly, many an innocent man has fallen a victim to an unfortunate conjunction of circumstances. The danger in every

¹ *The Theory of Knowledge*, p. 422.

case of circumstantial evidence is that facts really pertinent to the question in hand may be overlooked, or neglected as immaterial. Especially is this apt to occur when the observer is biased in favour of a hypothesis, perhaps hastily formed. There are always some facts inconsistent with a false hypothesis if only they could be found.

§ 3.—In history the indirect method of establishing hypotheses is the only one available, and the same applies to a great extent in all branches of social science. Owing to the extreme complexity of the subject-matter, dealing as it does with all the motives and circumstances which can influence human conduct, it is impossible to apply the direct inductive methods, for the phenomena cannot be isolated for examination, even in the present. Moreover, history suffers from the exceptional initial difficulty of having to rely upon testimony, often of an inferior character, for its facts. Thus, throughout, "History is not . . . a science of observation, but a science of reasoning. In order to use facts which have been observed under unknown conditions, it is necessary to apply criticism to them, and criticism consists in a series of reasonings by analogy. The facts as furnished by criticism are isolated and scattered; in order to organize them into a structure it is necessary to imagine and group them in accordance with their resemblances to facts of the present day, an operation which also depends on the use of analogies . . . In order to frame its arguments from analogy, it must combine the knowledge of the particular conditions under which the facts of the past occurred with an understanding of the general conditions under which the facts of humanity occur." ¹

The In-
direct
Method in
History.

¹ Langlois and Seignobos, *Introduction to the Study of History*, p. 317.

In pursuing such a method two opposite dangers present themselves. On the one hand is the danger of making history a mass of mere empirical facts with no generalizations to bind them together; on the other, that of inferring consequences from abstract principles gathered from an analysis of general human nature, and advancing these as true without bringing them to the test of comparison with actual facts. It is the tendency to fall into this last error which has brought such subjects as the philosophy of history and the science of political economy into some disrepute. But to assume that such branches of knowledge are valueless because some of their exponents have adopted too abstract a treatment is to fall into the opposite error. The subject of education presents another example. On the one hand we have the 'practical' teacher who despises 'theory' and values only the facts of his own experience. On the other, we have the arm-chair 'theorist' who deduces laws from the general principles of logic and psychology, or even from such a vague conception as Rousseau's 'Nature,' and advances them as rules to be put into practice irrespective of circumstances. The wise educator stands between the two.

The Indirect
Method in
Geology and
Biology.

§ 4.—Sciences such as geology and biology, which attempt to explain the origin of the present from the evidence of the material traces left by the past, must continually resort to the indirect method. In such investigations the inductive methods considered in the last chapter are applicable mainly in the verification of consequences deduced from hypotheses which go behind the facts in attempting to explain them.

Example
from
Geology.

We will borrow for analysis a typical example from geology. In the account of the glacial phe-

nomena of the British Isles contributed by my colleague, Mr. P. Kendall, to Professor Wright's *Man and the Glacial Period*, we read : " From the neighbourhood of Lichfield, through some of the suburbs of Birmingham, and over Frankley Hill and the Lickey Hills to Bromsgrove, there is a great accumulation of Welsh erratics, from the neighbourhood, probably, of Arenig Mawr." ¹ The problem is to account for the transportation of these boulders some sixty or seventy miles from their source.

Two hypotheses were advanced ; one that they had been borne by marine ice during a period when the land was submerged, the other that they had been transported by glaciers. The consequences of each of these hypotheses must be deductively inferred and then tested by comparison with the facts.

Mr. Kendall first explains exactly what the glacial hypothesis involves. " During the early stages of the Glacial period the Welsh ice had the whole of the Severn Valley at its mercy, and a great glacier was thrust down from Arenig, or some other point in central Wales, having an *initial direction*, broadly speaking, from west to east. This glacier extended across the valley of the Severn, sweeping past the Wrekin, whence it carried blocks of the very characteristic rocks to be lodged as boulders near Lichfield ; and it probably formed its terminal moraine [in that neighbourhood]. As the ice in the north gathered volume it produced the great Irish Sea Glacier, which pressed inland and down the Vale of Severn . . . and brushed the relatively small Welsh stream out of its path, and laid down its own terminal moraine in the space between the Welsh border and the Lickey Hills." ² Of course such a hypothesis is based on many traces left in the forma-

¹ *Op. cit.*, p. 150.

² *Op. cit.*, p. 151.

tion of the land, the force of which would only be felt by a geologist. It grows out of the facts open to observation, though it goes much beyond them in its mental construction of a set of conditions so different from the present state of things.

Mr. Kendall then proceeds to examine the evidence in detail, comparing it at each step with the consequences which can be inferred both from the hypothesis of glacial agency and from that of the action of marine ice. Each group of facts is thus made a crucial instance and shown at once to support the former supposition and to conflict with the latter.

The first step is to dispose of apparent exceptions by showing that on analysis they really negate the hypothesis they appear at first sight to support, and confirm that with which they seem on a casual view to be in conflict. "Within the area in England and Wales covered by the Irish Sea Glacier all the phenomena point to the action of land-ice, with the inevitable concomitants of sub-glacial streams, extra morainic lakes, &c. There is nothing to suggest marine conditions in any form except the occurrence of shells or shell fragments; and these present so many features of association, condition, and position inconsistent with what we should be led to expect from a study of recent marine life, that conchologists are unanimous in declaring that not one single group of them is on the site whereon the shells lived. It is a most significant fact—one out of a hundred which could be cited did space permit—that in the ten thousand square miles of, as it is supposed, recently elevated sea-bottom, not a single example of a bivalve shell with its valves in apposition has ever been found! Nor has a boulder or other stone been found encrusted with those ubiquitous marine

parasites, the barnacles.”¹ Thus, when the presence of sea shells is analysed, the mode of that presence is seen to be inconsistent with the hypothesis of marine-ice, which the bare unanalysed fact of their presence seemed at first sight to support. On the other hand, though this presence of shells is not a direct consequence which can be inferred from the hypothesis of land-ice, yet it is not inconsistent with that supposition. For this hypothesis assumes the existence of the Irish Sea prior to its invasion by the glacier. When this invasion took place the glacier would be likely to sweep up shells from the shell-banks on the sea-floor. Mr. Kendall tells me that when he advanced this explanation it was unsupported by any observed case of actual shell-transportation by glaciers, but that in 1897, several years after the above was written, a glacier thus carrying shells was discovered in Spitsbergen. This may be said to practically complete the evidence required on the point.

Having disposed of the apparent disagreement between the theory of land-ice and the facts, Mr. Kendall proceeds to summarize the positive evidence, and to show that this evidence negates the marine-ice supposition. “The evidences of the action of land-ice within the area are everywhere apparent in the constancy of direction of—(1) Striæ upon rock surfaces. (2) The terminal curvature of rocks. (3) The ‘pull-over’ of soft rocks. (4) The transportal of local boulders. (5) The orientation of the long axes of large boulders. (6) The false bedding of sands and gravels. (7) The elongation of drift-hills. (8) The relations of ‘crag and tail.’ There is a similar general constancy, too, in the directions of the striæ upon large boulders. Upon the under side

¹ *Op. cit.*, pp. 151—152.

they run longitudinally from south-east (or thereabouts) to north-west, while upon the upper surface they originate at the opposite end, showing that the scratches on the under side were produced by the stone being dragged from north-west to south-east, while those on the top were the product of the passage of stone-laden ice over it in the same direction.

“Such an agreement cannot be fortuitous, but must be attributed to the operation of some agent acting in close parallelism over the whole area. To attribute such regularity to the action of marine currents is to ignore the most elementary principles of marine hydrology. Icebergs must, in the nature of things, be the most erratic of all agents, for the direction of drift is determined, among other varying factors, by the draught of the berg. A mass of small draught will be carried by surface currents, while one of greater depth will be brought within the influence of under-currents; and hence it not infrequently happens that while floe-ice is drifting, say, to the south-east, giant bergs will go crashing through it to the north-west. There are tidal influences also to be reckoned with, and it is matter of common knowledge that flotsam and jetsam travel back and forth, as they are alternately affected by ebb and flood tide.

“Bearing these facts in mind, it is surely too much to expect that marine ice should transport large boulders (how it picked up many of them also requires explanation) with such unfailing regularity that it can be said without challenge, ‘Boulders in this district [South Lancashire and Cheshire] never occur to the north or west of the parent rock.’ The same rule applies without a single authentic exception to the whole area covered by the eastern branch of the Irish Sea Glacier; and hence it comes about

that not a single boulder of Welsh rock has ever been recorded from Lancashire.”¹

Throughout this example we see the attempt to establish the hypothesis, not only by showing that it will explain the facts, but by proving that the only other possible supposition fails to do so.

§ 5.—Passing now to the establishment of those wider truths to which we referred at the beginning of this chapter, we will take as our example the development of the Theory of Gravitation.

Establish-
ment of
Theory of
Gravitation:

The idea that material bodies attract each other had been familiar to the ancient Greek philosophers, but it only became useful to science when it was made definite by measurement. The first step was taken by Galileo in the first half of the seventeenth century. From the consideration of a great number of facts he was led to the hypothesis that all bodies fall with equal rapidity under the attraction of the earth, independently of both their size and their material. By letting various bodies fall at the same moment from the top of the leaning tower of Pisa he gave an approximate verification of this hypothesis, attributing the trifling differences in the times they took to reach the ground to the greater resistance offered by the air to light than to heavy bodies.

*Empirical
Laws of
Falling
Bodies.*

Newton succeeded in making the verification much more exact “by the simple and elegant contrivance of enclosing in a hollow pendulum the same weights of a great number of substances the most different that could be found in all respects, as gold, glass, wood, water, wheat, &c., and ascertaining the time required for the pendulum so charged to make a great number of oscillations; in each of which it is clear the weights had to fall, and be raised again successively, without loss of time, through the same

¹ *Op. cit.*, pp. 152—153.

identical spaces. Thus any difference, however inconsiderable, that might exist in the time of one such fall and rise would be multiplied and accumulated till they became sensible. And none having been discovered by so delicate a process in any case, the law was considered verified both in respect of generality and exactness.”¹ Here, as Newton was studying one force only, he maintained all other conditions—such as the resistance of the air—constant by the simple device of using the same pendulum.

Galileo had also advanced the hypothesis that the spaces described by falling bodies must vary as the squares of the times, and he based this on the supposition that this was the simplest law that could be assigned. This argument, of course, was somewhat insecure, but the truth of the hypothesis was approximately verified by experiment.

*Empirical
Laws of
Planetary
Motion.*

Nearly forty years before Galileo's enunciation of the laws of falling bodies Kepler had entered upon his memorable investigations into the motions of the planets. The current theory was that each planet revolved round the sun in a circular path, and it was only after the failure of many attempts to reconcile the observed positions of the planets with this theory, by moving the centres of the circles in all kinds of ways away from and towards the sun, that Kepler at last hit on the true hypothesis of an elliptical orbit. The final outcome of his researches was the enunciation of the three laws still known by his name—that each planet revolves round the sun in an elliptical path, having the sun in one of the foci; that it revolves with such a velocity that a straight line drawn from it to the sun passes over equal areas in equal times; and that the squares of the number of days taken by the planets to complete a

¹ Herschel, *Discourse on Natural Philosophy*, § 179.

revolution are proportional to the cubes of their mean distances from the sun.

As established by Kepler these were merely empirical laws, descriptive of observed facts. "The laws as they came from Kepler's hands stood out as three independent truths; thoroughly established but wholly unsupported by any explanations as to why these movements, rather than any other movements, should be those appropriate for the revolutions of the planets." ¹

It was the great achievement of Newton to combine these empirical laws with those of falling bodies, and from the combination to conceive the famous theory of universal gravitation, in which they all found their explanation. "Newton's grand discovery bound together the three isolated laws of Kepler into one beautiful doctrine. He showed not only that those laws are true, but he showed why they must be true, and why no other laws could have been true." ²

This theory was not, however, reached all at once. Newton first guessed that the force of gravity might extend to the moon, and retain it in its orbit. Immediately, he proceeded to deduce by mathematical reasoning the results of this hypothesis, assuming that the empirical law of the square of the distance held true between earth and moon. Working with the reputed distance of the moon from the earth, he calculated that gravity should draw it towards the earth through more than fifteen feet every minute. But "according to Newton's calculations, made at this time, the moon, by her motion in her orbit, was deflected from the tangent every minute through a space of thirteen feet. . . . The difference seems small, the approximation encouraging, the theory

*Gravitation
applied to
Moon.*

¹ Ball, *Story of the Heavens*, p. 117.

² *Ibid.*

plausible ; a man in love with his own fancies would readily have discovered or invented some probable cause of this difference. But Newton acquiesced in it as a disproof of his conjecture, and 'laid aside at that time any further thoughts of this matter.'"¹ Some fifteen or sixteen years after, Newton found "he had been mistaken in the magnitude of the earth, and consequently in the distance of the moon, which is determined by measurements of which the earth's radius is the base."² He repeated his calculations, and his former supposition was now found to agree with the phenomena with remarkable precision. The law of gravitation was thus proved to apply to the moon.

*Gravitation
extended
to Planetary
Motion.*

To conceive that the same law would explain the motions of the planets round the sun was a natural development. Indeed, that the different planets are attracted to the sun by a force which varies inversely as the square of the distance was already known to be approximately true. Newton, however, starting with the facts of planetary motion as expressed in Kepler's laws, showed by rigorous mathematical reasoning that these laws imply the law of gravitation as their ground, and are a necessary consequence of that law.

Difficult and intricate as was the mathematical reasoning involved in this further verification of the theory of gravitation, the next step was more complicated still. It was to conceive gravity as a mutual attraction of all the members of the solar system.

If this were true, then the moon, being attracted by the sun as well as by the earth, would move sometimes faster and sometimes more slowly than if attracted by the earth alone. Further, the same

¹ Whewell, *History of the Inductive Sciences*, vol. ii., p. 122.

² *Ibid.*, p. 123.

result would hold with the satellites of the other planets ; and if the planets attract each other, their movements would also show divergencies from those that would be due to the single attractive power of the sun. Here, then, were a set of deviations, small indeed in quantity, but excessively complicated in their nature. Newton worked out by a wonderful course of geometrical reasoning, all the chief perturbations in the case of the moon, and indicated how a similar train of inference could be applied to the other satellites. When his results, thus deductively attained, were compared with the observations of Flamsteed, they were found to be surprisingly accurate.

The final step in the development of the theory of gravitation was taken when it was made applicable to all particles of matter, and not simply to those concrete bodies of sensuous perception to which it had hitherto been applied. Of this supposition, too, Newton proceeded to calculate the results, and he applied his reasonings to explain "the figure of the earth, the tides, the precession of the equinoxes, the regression of the nodes of a ring such as Saturn's, and of some effects which, at that time, had not been ascertained even as facts of observation ; for instance, the difference of gravity in different latitudes, and the nutation of the earth's axis. It is true, that in most of these cases, Newton's process could be considered only as a rude approximation. . . . Nevertheless the form and nature of the conclusions which [he] did obtain, were such as to inspire a strong confidence in the competency of his theory to explain all such phenomena as have been spoken of." ¹

*Gravitation
extended
to all
Particles
of Matter.*

In all essentials, then, this magnificent discovery

¹ Whewell, *op. cit.*, vol. ii., p.135.

—certainly one of the greatest ever made—was the work of one mighty intellect. By it, as Whewell remarks, “Astronomy passed at once from its boyhood to mature manhood.”¹ The task of subsequent astronomers has been only to work out the results of the theory in more detail and with more perfect accuracy. The scope of the principle has been continually extended, till, as Sir Robert Ball tells us, “when we extend our view beyond the limits of our Solar System to the beautiful starry systems scattered through space we find even there evidence of the great law of universal gravitation.”²

Even the rough and meagre outline we have been able to give of the process of this great induction brings out clearly how small a part in it was played by direct inductions from sense-experience. Beyond the empirical laws of falling bodies and of the movements of the planets such inductions could not go. All the later steps were taken by the indirect method we are considering in this chapter; and these steps could have been possible only to one who possessed enormous mathematical knowledge and capacity. “It was the extraordinary power with which Newton traced out geometrically the consequences of his theory, and submitted them to repeated comparison with experience, which constitutes his pre-eminence over all physicists.”³

It must be noted that the theory goes far beyond sense-experience. “The law asserts that every particle of matter in the universe attracts every other particle, with a force depending on the masses of the particles and their distances. We cannot know the force acting on any particle unless we

¹ Whewell, *op. cit.*, vol. ii., p. 137.

² *Op. cit.*, p. 122.

³ Jevons, *The Principles of Science*, p. 556.

know the masses and distances and positions of all other particles in the universe.”¹ Of course, such knowledge is unattainable, and our verifications of the law can, therefore, never be more than partial and approximate. But as man’s powers of exact computation and precise observation are increased, the verifications become more and more exact, and in astronomy especially they have attained a truly wonderful degree of precision. We are, therefore, justified in believing the law of gravitation to be exactly true. In other words, our knowledge is more exact than our actual observations can ever be.

Lastly, the law goes beyond sense-perception in that it not only describes, but explains phenomena. As we saw, Kepler’s laws were merely descriptive; they brought all possible observations of a planet’s positions under general formulæ. But the theory of gravitation is a causal law, explaining those motions by showing them as the necessary consequences of mechanical principles. Thus, the theory emphasizes the doctrine that knowledge is a mental construction suggested by observed facts, and continually verified by appeal to them, but not confined to the products of sense-perception.

¹ Jevons, *The Principles of Science*, p. 458—459.

CHAPTER XVI

DEFINITION, CLASSIFICATION, AND EXPLANATION

Aim of
Methods of
Knowledge.

§ 1.—To know is to be able to explain. The aim, therefore, of all the methods of developing knowledge which we have considered is the explanation of the experiences of humanity. That goal is far from being reached, but it is one towards which mankind has been, on the whole, continuously progressing. The ideal of explanation is to show both the place and the function in the system of the universe of that which is to be explained. This implies a knowledge both of the nature of the phenomenon in question and of its relations to other phenomena. Thus we see that the stage of explanation by system takes up into itself the two preceding stages of interpretation of the world which we considered in the first two chapters.

We saw, further, in chapter v, that to each stage of interpretation there broadly corresponds a suitable form of judgment. The nature of things is most appropriately expressed in the categorical judgment, their relations to other things in the hypothetical judgment, and their union into system in the disjunctive judgment, which takes up the other two forms into itself.

Lastly, our examination of the inductive methods of obtaining knowledge from a direct study of the world has made it clear that the same enquiry which aims at establishing the existence of universal law must also bring to light the nature of the things related. It is evident that the precision which can be given to a judgment of the form "If S is M it is P" is directly dependent on the exactness of our knowledge of the nature of S, M, and P.

Our attention has, however, been mainly concentrated hitherto on the establishment of laws; we must now examine the mutually involved processes of definition and classification.

§ 2.—Like all attempts at organizing knowledge, classification and definition have their roots in the previously unorganized experiences of humanity. "Ages before the logician, or any one else who deals with systems, had a hand in the matter, the necessities of common life had been at work prompting men to group the things which they observed. All names imply the recognition of groups, and a great number of names imply a subordination of groups, so that at the earliest stage to which we can transfer ourselves we find that we are already in possession of a rudimentary classification; and that we cannot even talk or think about the things without an appeal to this."¹ Of course, every such grouping was based on the recognition of common qualities, and the name implied that these qualities were present in any case in which it was applied. The rudimentary classification consequently involved a rudimentary definition, for definition is merely the statement of the common qualities which determine the classification.

Develop-
ment of
Definition.

But, as was shown in chapter iii, words vary in

¹ Venn, *Empirical Logic*, p. 322.

their import according to the context in which they occur. For long ages, men did not attempt to make explicit the common element in these numerous occasional meanings, with the natural result of a want of precision in thought, which became more and more pronounced as both life and thought became more complex. Socrates was the first who began to enquire systematically what general meaning could be found as a constant element in all the specific meanings of words as used in actual speech. He enquired, as Xenophon tells us, into "what was pious, what impious; what honourable, what base; what sobriety, what excess; what courage, what cowardice; what a state, what a statesman; what the government of men, what one who was capable of governing them. And so too on other subjects, the knowledge of which he thought rendered men honourable and good, but ignorance of them fit only to be designated as no better than slaves."¹

The method of Socrates in these enquiries, as it is shown us in the writings of Plato and Xenophon, was, in all essentials, the method by which modern science investigates the nature of reality. It was to examine different cases in which a term was applied, and by comparing them with cases in which the contrasted term was used, to try to determine what was the essence of the idea of which each word was a symbol. Nor was this—or is it ever—a question of *mere* words. For, as all the meaning of a word must be justified by the reality to which it refers, a determination of meaning is a determination of facts of reality. A verbal element dissociated from any meaning is, indeed, not a word at all. If a native of China were to address me in his native tongue, the sounds he uttered would be words to him, but

¹ *Memorabilia*, Bk. I., c. i.

not to me. True learning of words is, then, true learning about facts; and, as has been already said, there can be no learning of facts without words, or at any rate, without some kind of language-signs.¹

The aim, then, of such enquiries as those of Socrates is to discover what common nature exists in certain facts to justify the marking of them by the same word. The expression of such a common nature is a statement of the general meaning of the word, and this meaning, regarded as a mental fact, is called a *concept*. All ideas corresponding to words are of the nature of concepts, for they are all, to some extent, a grasp of meaning. But the term 'concept,' when used strictly, implies a meaning or idea which is precise and accurate, and such a concept can only be attained by a careful process of analysis of reality, such as Socrates began, and which we can carry out much more accurately, and apply to a much greater range of reality, by the aid of the inductive methods. The final outcome of such a process is definition.

§ 3.—Definition, then, is an expression of general meaning. It does not, however, necessarily include all that general meaning. The aim of definition is to be as brief as possible, consistently with precise accuracy. But any analysis of the common nature of things which is pushed very far shows that common qualities are in certain cases so connected together that some can be derived from others. For example, amongst the qualities common to all right-angled triangles are those of being inscribable in a semi-circle, and of having the square on the hypotenuse equal in area to the sum of the squares on the sides. But both these characteristics, as well as many others, can be deductively inferred from the fact that the triangle is right-angled. These derived

Nature of
Definition.

¹ Cf. pp. 45—46.

qualities, which are technically called *Properties*, are, then, not expressed in the definition, because they are implied by stating in it the characteristic of having a right-angle. Similarly, such properties as being able to invent tools and generally adapt his material environment more or less perfectly to his own needs, to study various branches of knowledge, to write poetry, paint pictures, establish systems of government, etc., are all properties of man inferrible from his possession of a rational will, and, therefore, would not be included in the definition.

Again, there are other qualities which are sometimes common to a whole class, and which we yet do not consider essential to the nature of that class. Were they absent in any case we should still apply the name, so long as what we consider the more fundamental qualities were present. Thus, all swans known before the discovery of Australia were white, but when birds essentially similar in structure and mode of life, though black in colour, were found, no hesitation was felt in including them in the class swans. Such qualities are called *Accidental Qualities* or *Accidents*. It is evident that every individual thing has also many such accidental qualities; in man we call them 'personal peculiarities.'

In some cases, as in those just taken as examples, it is easy to see which are the derived, and which the more fundamental qualities. But not infrequently, especially in mathematics, this is a matter of arbitrary choice. For example, the equality of sides and of angles in an equilateral triangle are inferrible from each other. Which of these qualities we include in the definition, and which we consequently relegate to the rank of a property, is purely a matter of choice. Outside mathematics it is in many cases impossible, at any rate with our present

amount of knowledge, to trace any such necessary connexion at all.

It follows, then, that a definition states a more or less arbitrarily chosen group of attributes, which form what is technically called the *connotation* of the word. It enunciates what we esteem the most important qualities. But importance is always relative to some purpose or theory. Hence, "a new principle or theory will often effect a complete change in the order of dependence or importance in which the attributes are regarded."¹ Many examples occur in the history of mathematics, but the most interesting to the general reader is the revolution in this respect introduced into the biological sciences by the theory of evolution. "It is not so much that we have discovered new facts about the plants and animals as that a new theory has completely altered the relative importance of the facts that were already known."²

Our definitions, then, cannot claim finality. Any new development in knowledge may lead to a profound modification of many definitions. Thus, with scientific terms, as Dr. Venn says, "their growth is their life."³ Every change of definition is accepted only after a vast amount of careful and critical research, and, therefore, implies an advance in knowledge, either of the facts involved or of the theory which unites them and gives them a meaning.

With the words of ordinary language greater stability is desirable, for words used by a whole nation must change their meaning, and consequently their application, but slowly, if at all, or communication by language would become increasingly difficult, especially between one generation and another, if, indeed,

¹ Venn, *op. cit.*, p. 284.

² *Ibid.*, pp. 285—286.

³ *Ibid.*, p. 288.

it did not become impossible. Of course, meanings do change in every living language, and travellers amongst savage tribes with a purely oral language tell us that this change is so rapid that in the course of a very few years what is practically a new language has developed. The reduction of language to writing, the diffusion of books made possible by printing, and the general ability to read them, do much to increase the stability of a language. During the last three centuries, for example, many words have changed somewhat in meaning, as is evident from a comparison of Shakespeare and of the Authorized Version of the Bible with current usage. But the change has been comparatively small, and we have no difficulty in understanding Elizabethan writers. Thus, the treasures of the past are open to us in a way they could not be did language change rapidly.

Definition
and other
Modes of
stating
Meaning.

§ 4.—Again, as every definition states a more or less arbitrarily chosen group of common attributes, it is evident that it is only one way of stating meaning. But it is the most precise way, for it expresses just what the most competent authorities regard as the meaning of the word ; in other words, it expresses the value of the term in the existing body of knowledge. Definition is, therefore, not a question of individual choice and caprice, but of established usage, and the final appeal must be to those who are most competent by knowledge to determine that usage. This is recognized in science, and the whole essence of scientific language is the exactness and precision with which it uses its terms. With ordinary speech there is much less precision, simply because it expresses much less exact thought. “As long as popular thought is vague its language must be vague ; nor is it desirable too strictly to correct the language whilst the thought is incorrigible. Much of the effect of

poetry and eloquence depends upon the elasticity and indirect suggestiveness of common terms.”¹

But this want of precision in language is a fruitful source of misunderstanding and of confusion of thought, and it is obvious that it must be confined within recognized, if not very precise, limits. In other words, whatever else a word may imply in any particular passage it must at least be held to imply a fixed nucleus of general meaning. The statement of this is the definition. This may not be explicitly present to the mind of either the user or the receiver of the word, but it must be held to be implied, and if the word is used with a correct reference to reality, that assumption is justified. To make this unconsciously implied meaning clear to the mind is to make an advance in knowledge and in clearness of thought. With the individual, as with the race, knowledge of meaning is at first very imperfect, and consists in a few of the striking qualities common to the objects to which the name is applied. The essential thing for the purposes of ordinary communication is correct reference to reality. If a young child is asked what he means by a ‘cat,’ he will probably point to one, if one is in sight, and say ‘a thing like that.’ It is only by judicious questioning that he can be led to make explicit in his mind the meaning which is really there, and to refer to the cat’s fur, shape, mode of utterance, power of scratching, and other obvious qualities as forming the meaning or *content* which ‘cat’ has for him. And in many cases the application of the name to particular examples—its *denotation*, as it is technically called—remains a very prominent part of the meaning to us. So long as we have sufficient knowledge of the nature of things to guide us in our practical needs, both of

¹ Carveth Read, *Logic, Deductive and Inductive*, p. 272.

thought and of communication, we do not push our enquiries further. "To the very last, in most of us, the conceptions of objects and their properties are limited to the notion of what we can *do with them*. A 'stick' means something we can lean upon or strike with; 'fire,' something to cook, or warm ourselves, or burn things up withal; 'string,' something with which to tie things together. For most people these objects have no other meaning."¹ It is only when, for any reason, we require our knowledge of some class of things to be very exact, that we strive to obtain a precise definition. The power to give an exact definition, then, may be said to be a mark of scientific thought, as distinguished from the looser thought of every-day life.

It is now clear that inability to give a precise definition is by no means a sign of inability to think and speak correctly and intelligently of the matter in hand, so far as we require to do so in ordinary life. Many people are surprised to find they cannot give an accurate definition of such common terms as 'table' or 'cow,' if they are called upon to do so. It does not follow that they know nothing about tables and cows. They may even be carpenters or graziers, and so know a great deal about them, and yet be unable to define their name, though they could give a more or less full and accurate description of the things to which that name applies. This often only means that they have never closely analysed their knowledge. In other cases it implies that though they know many of the common qualities they do not know all those which are conventionally regarded as the definition of the name. In all cases it shows that the meaning has never been separated in thought from the actual things, or the mental

¹ James, *Talks to Teachers on Psychology*, p. 59.

images of those things, in which that meaning is exemplified.

It follows that the definition of an unfamiliar word, no matter how correct it may be, may convey little or no information to one who, by analysis of other cases, has never reached the elements which are combined in that definition. As Dr. Venn says: "It must be understood . . . that definition is but one way, and this a somewhat technical way, of conveying a meaning to any one who is in doubt. To raise the requisite experience at first hand, or by exercise of imagination, may often be the most effective plan."¹ In brief, definition is always abstract, and says but little to those who, like young children, cannot detach their thoughts from the concrete experiences of life. Definition, like the recognition of law, is the end, not the beginning, of a process of acquiring knowledge.

§ 5.—Again, the unit of thought-expression is the sentence; the idea contained in the sentence is grasped as a whole, and not built up by joining together the meanings of the individual words which constitute it. It follows that the power to understand a sentence in its context, and the power to define the separate words of which that sentence is composed, are largely independent of each other; either may exist in the absence of the other. We see, then, that in actual thought the demand for a definition is always more or less exceptional. And when such a demand is made, it always implies both knowledge and ignorance. There is ignorance of the true force of this particular word, but knowledge of much of the context in which it occurs. Without this combined knowledge and ignorance the mind would not ask for a definition. Such a demand may

Limits of
Definition.

¹ *Op. cit.*, p. 279.

be satisfied either by an appeal to authority or by a personal investigation of the facts. The former is, of course, the more rapid and usual method, but the latter, if thoroughly carried out, leads to the more thorough knowledge. It is well, then, to encourage the search for definition. But it must be recognized that there are limits to such a search, for every word cannot be defined. We can get to nothing more simple than the final results of an analysis of sense-impressions. We can analyse an actual object, for instance, into its weight, form, colour, &c., and we can analyse the form into its geometrical elements. But we cannot go further than this, and when we have reached the end of the analysis we have reached the limit of the power of definition. We cannot define 'blue,' or 'sweet,' or 'pleasant'; for we have no simpler forms of language to express such unanalysable elements of experience.

Meaning of
Proper
Names.

Again, all definition implies common qualities possessed by a class, but separated in thought from the individuals in which they are found. In the class of words known as 'Proper Names' this separation never takes place. The very term 'proper' implies that such a name is peculiar to the individual who bears it. A proper name is not given to a person or place because of the presence of certain qualities; therefore, it does not imply any qualities common to the various individuals who may happen to bear the same name. All 'men' are related to the general idea 'man,' as instances in which that general idea is exemplified. But there is no such general idea corresponding to 'Smith' or 'Jones.' Each particular Jones has, of course, innumerable attributes, and these are known more or less to his friends, and give meaning to his name. But the name is not given because he possesses those

attributes, and it would continue to be given if they were fundamentally changed. "Macaulay after his mind was gone was still Lord Macaulay and his father's son, but what else was he that he had been?"¹ And the attributes of one individual bearing a certain proper name differ from those of every other individual who bears it. "The same word 'John' means one person to me if I use or hear it in one company, and quite another in a different society."² No doubt, each John has attributes in common with other Johns, but the proper name does not imply any of those attributes. The name does not rest on any analysis of qualities, as does every general name, but is given to the individual as one definite piece of reality. Hence "the name of an individual means all that that individual is, but precisely on that account it is not such as a general name."³ A proper name has, then, no general meaning which can be expressed in a definition; its meaning is always individual, and serves only as a means of identification.

§ 6.—Having reached a definition, we must next ask whether it is satisfactory. There are certain recognized rules to which a logically perfect definition must conform, but these are to be regarded not so much as directions for forming a definition as tests of their merit after they are formed.

Rules of
Definition.

(1) With regard to content, the one and sufficient condition of validity is that *the definition precisely states the recognized connotation of the word, and nothing else*. If it includes a 'property' the definition is made unnecessarily long and cumbrous; if it mentions an 'accident' it may unduly limit

¹ Bosanquet, *Logic*, vol. i., p. 54.

² Hobhouse, *The Theory of Knowledge*, p. 106.

³ *Ibid.*, p. 107.

the application of the definition ; if it omits part of the connotation, its application may be improperly extended.

(2) With regard to expression, the aim is to secure definiteness and precision. Thus the definition

(a) *Should not be mere tautology.*

(b) *Should not be stated in vague language.*

(c) *Should not be negative unless the whole meaning is a negative one.*

With regard to (a), the content of an idea is evidently not expressed by giving that idea a new name. For example, to say "Veracity is truth," does not state the qualities of character and conduct which compose our idea of the virtue in question. It by no means follows, however, that such tautologies are useless. They generally consist in affirming that a new and unfamiliar term means exactly the same as a familiar one. A child might well know what truth is, and yet not recognize it under its new label of "veracity"; to learn that the two terms are synonymous increases his knowledge of language though not of virtue. The common definition, "A noun is a name" comes under this head. Logically it is a tautology, but practically it enables the child to ticket a familiar idea with a technical label. To ask him to define a name would simply be to confuse him, for it would be to insist on an analysis of an idea so simple to him that no analysis is required, and no analysis would make it clearer.

(b) The demand for clearness is most important. The definition of a name as "a word taken at pleasure to serve for a mark which may raise in our minds a thought like to some thought we had before, and which, being disposed in speech and pronounced to others, may be to them a sign of what thought the

speaker had or had not before in his mind,"¹ whatever may be its merits for a philosophical enquiry into language, obviously does not make the idea clearer to the ordinary mind. Similarly, a child would probably not receive much assistance in understanding what "network" is from the definition given by Dr. Johnson—"anything reticulated or decussated at equal intervals, with interstices at the intersections." Such examples make it clear that a pedantic insistence on definition may do much to hinder the comprehension of meaning. The ordinary dictionary recognizes this, and the majority of the 'definitions' of the words of common language which it contains are descriptions rather than definitions in the logical sense. Common sense tells us that such descriptions are often exactly what we want. To see a net and think out its purpose gives more content to the idea than to learn not only such a definition as that of Dr. Johnson, but any definition that could, in all probability, be framed.

(c) The rule against negative expression is really included in that for content, for to say what a thing *is not* is certainly not to give its connotation, the function of which is to say what it *is*. Euclid's definition of a point is an example of this fault. It omits the essential positive quality of position in space, and it is only because we are led to interpret it spatially by the influence of the context in which it occurs, that we can give any meaning to it at all. A few words whose meaning is essentially negative—such as unequal, alien—are, however, most aptly defined in a negative form. But it should be borne in mind that the mere presence of a negative prefix does not limit a word to a purely negative meaning; 'unhappy,' for ex-

¹ Hobbes, *Computation or Logic*, ch. ii.

ample, means more than mere absence of happiness, it implies the presence of a certain amount of positive misery.

Nature of
Classifica-
tion.

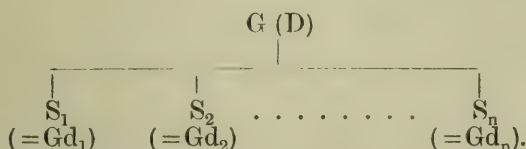
§ 7.—So far we have considered only definition, but it must be remembered that definition and classification are correlative, and proceed together. Turning now to this other aspect, we see first that classification is a mental organization of experience on the grounds of recognized resemblances and differences. This includes, in the first place, the grouping of particular things, as of a number of objects under the term 'rose,' and, secondly, the grouping of classes, as 'rose' and 'lily' under 'flower.' That all classification is a *mental* construction must be insisted on. In exceptional cases such an organization may be carried out in the material world, as in a museum or library; but even then it existed mentally first. In other words, every class implies a definition, for it is based on the explicit recognition of a common nature.

Now it is evident that any particular thing can be thought under many classes. Every quality we can detect in it is a possible basis for classification. We could, for example, class all the material objects in the universe under distinctions of colour, and to some extent the artist does so. In practice we are guided by common sense and common speech, which embodies in this respect the common sense of our ancestors. We try to classify things so that the classification will be most serviceable to the special purpose we have in hand. The botanist and the medical man, for instance, would classify plants in very different ways, the market-gardener would give yet another classification, and so on. And to these various classifications would correspond various special definitions. This explains why a word often has a meaning in some particular science different, to

some extent, from its meaning in ordinary speech. The definitions of ordinary language are based upon the classification which deals in the most general way with the whole nature of the objects classified ; whilst those of a particular science may be based on a classification which emphasizes only one side of that nature.

§ 8.—The first and most obvious aim of every classification is to group exhaustively the whole denotation of the class-name, in such a way that the groups are exclusive of each other. This can only be secured if we confine ourselves to one basis in each step of the classification. To put the matter symbolically : If we have a class G which exhibits a quality D throughout its members, but in various forms $d_1 d_2 \dots d_n$, we may make D the principle on which we divide the wider class or *Genus* G , into the sub-classes, or *Species*, $S_1 S_2 \dots S_n$ —

Rules of
Classifica-
tion.



Here the classification is correct provided that in denotation

$$S_1 + S_2 + \dots + S_n = G.$$

This implies—

(1) That no individual is found in more than one class.

(2) That every individual which comes under G is found in one of the groups $S_1 S_2 \dots S_n$.

§ 9.—If we examine the connexion of this with definition we see that D is not part of the definition of G , because it appears under various forms. But it is part of the content or total

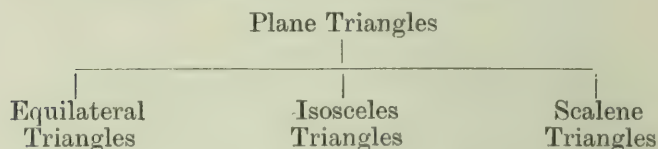
Classifica-
tion and
Definition.

meaning of G , or we could not use it as a basis for division. We have, therefore, enclosed it in brackets. If now we turn to the definition of the sub-classes, we see that every one of them possesses all the attributes included in the definition of G , and that they are marked off from each other by the various modifications of D , viz., $d_1 d_2 \dots d_n$. These are technically called the *Differences* of the co-ordinate species. Hence, it is evident that we may sufficiently define S_1 when we state its genus (G), and the particular difference (d_1), which marks it off from co-ordinate species under the same genus. In other words : in definition or connotation

$$S_1 = Gd_1; \quad S_2 = Gd_2; \dots S_n = Gd_n.$$

This is not only the most convenient, but also the most scientific way of expressing a definition, as it assigns both the place of the species in the classification and the basis on which that classification is made. It recognizes, too, that a demand for definition implies considerable, though incomplete, knowledge of the matter in hand ; it assumes that both G and D are known.

As a concrete example we may take—



Here the basis (D) is the mutual relations of the lengths of the sides, and of this we find three, and three only, possible modifications : equality of all three sides ; equality of two only ; inequality of all. Hence the classification is correct. The same genus might be classified on the basis (D_a) of the relations of the angles into right-angled, obtuse-angled, and acute-angled. We have, then, two possible classifica-

tions, each equally perfect, and each important for certain purposes. But they are independent, and to mix their results is to vitiate both. No doubt after classifying on one basis, we may proceed to apply the second principle to as many of our species as it is adapted to, and so take a second step in classification. For example, the three-fold classification on the basis of the relation of angles can be applied to the species isosceles and scalene in the classification based on the relations of sides, but not to the species equilateral.

Much confusion is frequently caused by neglect of this necessity for singleness of basis. Many school-books on grammar, for example, classify nouns into Proper, Common, and Abstract, where two bases are confused together, for the distinction between Proper and Common is founded upon the scope of the application of the name, whilst Abstract—which should be correlative with Concrete—refers to the kind of existence of the things named.

Or again, sentences are often divided into Simple, Principal, and Subordinate, which brings in yet another confusion. For whilst Simple and Complex are species under the genus Sentence, Principal and Subordinate Clauses are constituent parts of a complex sentence, and not species under that genus at all. As we have seen, we can define a species by naming its genus and difference, but we cannot say that a subordinate clause is a certain kind of complex sentence. The division of a complex sentence into its clauses is, then, an act of partition similar to dissecting a flower or an animal; its results are constituent parts of a whole, not species under a genus. This distinction must be clearly borne in mind; to enumerate parts which together constitute a whole, as, *e.g.* the counties of England as making up England, is quite a different mental process from

Classifica-
tion and
Partition.

enumerating species under a genus. One test of a logical classification always is that the genus can be predicated of each of the species.

Disjunctive
Classification.

§ 10.—We have seen that not only individuals, but classes can be grouped. In the examples we considered, each step of classification was on a new basis. Such a classification may be called *Disjunctive*; its whole aim is to give an exhaustive enumeration of particulars on the basis of certain resemblances. The value of such an arrangement is, as we have seen, relative to the special purpose with which it is made. So long as men thought the world was of comparatively recent origin, and that the different species of organized beings were unchangeable and divided from each other by gaps which never had been crossed, and never could be crossed, such a classification was all that was aimed at. It is emphatically the kind of organization of knowledge sought on the plane of sense-perception. Nor did the investigations of modern science at once change the aim. It was only when such researches as those of geology showed the immense age of the world, and demonstrated that existing species are really modern successors to species very different in character, that a new aim in classification was consciously adopted in science. This aim was to take a single principle as operative throughout the whole classification.

Subsumptive
Classification.

§ 11.—The classification thus became *Subsumptive*, that is, each sub-class was given a definite place in a hierarchy of classes exhibiting successive developments of one principle. In special cases, such classifications had, no doubt, been made at all times, e.g. the ordinary alphabetical arrangement of an index or a dictionary is based throughout on the conventional order of letters in the alphabet. And there is reason to think that in other cases such

a principle was really operative before it was consciously recognized. For it is obvious that we may classify by starting with a distinctly apprehended principle and proceed to develop its differences, or we may start with particulars and try to group them so as to bring out some principle. In this latter case the principle is operative before it is apprehended. As Darwin said, "Community of descent is the hidden bond which naturalists have been unconsciously seeking, and not some unknown plan of creation, or the enunciation of general propositions, and the mere putting together and separating objects more or less alike."¹

When one governing principle such as this is operative throughout, each class has a definite and fixed place in the classification. Thus the two terms, genus and species, require to be supplemented, and in the biological sciences we have such terms as 'order' and 'kingdom' wider than genus, and 'variety' as a narrower term.

The adoption of the genealogical principle also affected definition, for it gave quite a new aspect to the 'importance' of attributes. The characters which are important for indicating descent are often trifling from the point of view of the present life of the organism. "It might have been thought (and was in ancient times thought) that those parts of the structure which determined the habits of life, and the general place of each being in the economy of nature, would be of very high importance in classification. Nothing can be more false. No one regards the external similarity of a mouse to a shrew, of a dugong to a whale, of a whale to a fish, as of any importance."² On the other hand, rudimentary

¹ *Origin of Species*, p. 369.

² Darwin, *op. cit.*, p. 365.

organs which now play little or no part in the individual's life, are of high importance for indicating descent. "Organs in a rudimentary condition plainly show that an early progenitor had the organ in a fully developed condition ; and this, in some cases, implies an enormous amount of modification in the descendants."¹ The general or natural classification of organic beings is then "founded on descent with modification."² The dominant principle throughout is productive power.

Nor is this principle by any means confined to biology. "If we possessed a perfect pedigree of mankind, a genealogical arrangement of the races of man would afford the best classification of the various languages now spoken throughout the world ; and if all extinct languages, and all intermediate and slowly changing dialects, were to be included, such an arrangement would be the only possible one. Yet it might be that some ancient languages had altered very little and had given rise to few new languages, whilst others had altered much owing to the spreading, isolation, and state of civilization of the several co-descended races, and had thus given rise to many new dialects and languages. The various degrees of difference between the languages of the same stock, would have to be expressed by groups subordinate to groups ; but the proper or even the only possible arrangement would still be genealogical ; and this would be strictly natural, as it would connect together all languages, extinct and recent, by the closest affinities, and would give the filiation and origin of each tongue."³

We see the same principle of causation or productive power as the basis of classification applied

¹ Darwin, *op. cit.*, p. 424.

² *Ibid.*, p. 369.

³ *Ibid.*, p. 371.

more and more widely. "There is the physical classification into Solids, Liquids, and Gases. But these states of matter are dependent on temperature ; at least, it is known that many bodies may, at different temperatures, exist in all three states. They cannot therefore be defined as solid, liquid, or gaseous absolutely, but only within certain degrees of temperature, and therefore as dependent upon causation. Similarly, the geological classification of bodies, according to relative antiquity (primary, secondary, tertiary, with their subdivisions), and mode of formation (igneous and aqueous), rests upon causation ; and so does the chemical classification of compound bodies according to the elements that enter into them in definite proportions."¹ It is because the same principle cannot be applied to the elements themselves that chemistry remains so largely empirical.

We see, then, that throughout the realm of knowledge the idea of process is displacing the idea of things as the essential factor in reality. This is the natural result of the development of thought from the stage of sense-perception, through that of law, to that of system. To concentrate the attention of the young mainly on 'things' is, then, to arrest their mental development.

§ 12.—Of course the work of classification is not complete, and indeed, one does not see how it ever can be, for in the long ages of the past many data necessary to give such completeness to our present knowledge have utterly perished. But as knowledge advances, so the arrangement of contents of reality becomes more systematic and more accurate. Still, classification, like its correlate definition, can never be

Provisional
Character
of Classifica-
tion and
Definition.

¹ Carveth Read, *Logic, Deductive and Inductive*, pp. 267—268.

regarded as permanent, for such changes as have taken place in the past are going on in the present and may be anticipated in the future. As past types have been replaced by those we know, so they in turn will give place to others. Evolution is a matter not of the past alone, but of the present and future as well. However, the changes are very slow, and an existing classification may well hold for many thousands of years. Whilst then, as Mr. Carveth Read well puts it, "a classification . . . represents a cross-section of nature as developing in time,"¹ yet that cross-section largely corresponds to our knowledge. Our aim is to account for it. We may symbolize the development in time by a tree with its roots, trunk, branches, twigs, &c. We are amongst the branches and twigs, and we try to trace back their connexion with the root and so to get a knowledge of the kind of process which is developing. It may be that we must be forced to rest satisfied with tracing our origins back only to a few main branches; but even then we have gained much insight into that general principle of development which is the life of the universe.

Classifica-
tion and
Explan-
ation.

§ 13.—When a principle of development is made the basis of a classification there is but one step to explanation. But it is an important step. For classification merely describes and arranges; it gives no reason why the resemblances and differences on which it is based are what they are. It is the function of explanation to assign these reasons. This step is taken when the principle on which the classification is based is shown to be a law of change actually operative in reality. In biology when it was shown that variations are in fact transmitted by heredity, and that the variations which survive are

¹ *Op. cit.*, p. 266.

those which aid the possessors in the struggle to maintain existence, it was possible "to comprehend and follow out in some detail those changes in the form, structure, and relations of animals and plants which are effected in short periods of time, geologically speaking, and which are now going on around us."¹ Such changes are shown to be necessary consequences of the operations of natural law. So always ; explanation consists in bringing under law. A fact is to some extent explained when it is shown to be an instance of a law of causation ; an empirical law is explained when it is shown to be resolvable into wider and more elementary laws.

Professor Lloyd Morgan gives an instructive illustration of this, which we will venture to borrow : "A good many years ago, when I was a young student, a clever lad in Cornwall asked me the old question, 'Why does a stone fall to the ground?' Not wishing to put him off with the long-sounding words, 'Universal gravitation,' I replied, "Because it is heavy.' 'But a feather is not heavy and yet it falls to the ground,' was the prompt answer. I replied that the feather was relatively heavier than the air. The lad was silent for a moment, and then said, 'That's just one of the things I want to know : does the air fall to the ground and collect there like water in a pond, only we cannot see it because we are in it and it is invisible?' I saw that this lad's powers of comprehension were fully equal to the occasion, and explained the whole matter as best I could. I told him that he was quite right in supposing that the air, like the stone and the feather, was attracted by the earth ; I pointed out the universality of gravitation as a law of nature ; and then reverting to his first question, I said,

¹ Wallace, *Darwinism*, p. 7.

‘You now see that we explain the fall of the stone as a particular case of the action of a law that is universal in its generality.’ He was again silent for a moment, and then asked, ‘But what makes the earth attract it after all?’ I laughed, and said, ‘You’re a philosopher! Nobody can answer that question. Perhaps you may live to find it out, or at any rate to understand the solution when it comes, as come it may.’”¹

Limits of
Explanation.

§ 14—It must be acknowledged, then, that there are limits to all explanation. We cannot explain the ultimate nature of reality. The demand of thought is satisfied when concrete experiences can be shown as the interconnexions of general laws. “The composite is explained by construction out of the elementary; the elementary by interconnexion in a system; the system as a totality is that which requires no explanation, being itself the explanation of all its component parts.”²

It is further evident that in some cases we can push explanation further back than in others. The extent to which this can be done in any science indicates the advancement of that science towards perfection. When a science is complete “we are able by long chains of deduction to infer the individual fact without need of verification.”³ Thus physics and astronomy are much nearer perfection than is chemistry or medicine.

Logical
Explanation
and
Familiariza-
tion.

§ 15—All logical explanation, then, brings the particular under universal laws on the ground of fundamental identity. If the identity is not essential the explanation is a vain one. “Hence the attempts to help the understanding by familiar

¹ *Psychology for Teachers*, pp. 128—129.

² Hobhouse, *The Theory of Knowledge*, p. 449.

³ *Ibid.*, p. 404.

comparisons are often worse than useless. . . . The proneness to substitute familiarization for radical explanation is the easily besetting sin of human understanding: the most plausible of fallacies, the most attractive, the most difficult to avoid even when we are on our guard against it."¹ Such explanations are only illustrations by analogy, and their value depends on the strength of the analogy.² But it must be noted that 'explanations' of this kind are frequently the only ones which can be given to individual enquirers, for nothing is explanation to the individual which does not bring the new fact under what is already known to him. Care must then be taken that such an explanation is valid as far as it goes, that is, that the analogy is a strict one, or rather that both the thing explained and the relation which illustrates it are cases of the same wider law. Thus the late Professor Clifford wrote: "It is an explanation of the moon's motion to say that she is a falling body, only she is going so fast and is so far off that she falls quite round to the other side of the earth, instead of hitting it, and so goes on for ever."³ But when he goes on to add: "But it is no explanation to say that a body falls because of gravitation," on the ground that "this attraction of two particles must always, I think, be less familiar than the original falling body,"⁴ he is limiting 'explanation' to mere familiarization, and excluding from the term what is its very essence. In other words, he is confining explanation to a psychical phenomenon, a mere effect on an individual mind, and excluding it from its true place as the crowning point of logical theory.

¹ Carveth Read, *Logic, Deductive and Inductive*, p. 238.

² *Cf.* pp. 181—3.

³ *Lectures and Essays*, pp. 102—103.

⁴ *Ibid.*

CHAPTER XVII

LOGIC AND EDUCATION

General
Relation of
Logic to
Education.

§ 1.—We are now in a position to see the general bearing of logic on education. The function of education is to lead the child to find his true place and his true work in the universe. But before he can feel at home in the world, he must, at least to some extent, understand it ; so long and so far as he does not understand it, he is, as it were, a stranger in it. Logic analyses the process by which this knowledge and understanding of the universe have been gradually attained by the human race, and thus indirectly gives guidance to the educator in his task of leading the individual along the same path. The educator has to guide each pupil from the beginnings of knowledge in sense-perception, through the second stage of recognition of law, into the third stage, in which it is seen that all laws must find their reason and explanation in system.

It seems obvious that he who has made this process clear to his own mind will be better fitted to guide others than he who has not done so. He should have acquired logical habits of thinking, and these habits will influence his conduct and his teaching. Logic will not make him reason well, but

it will help him to do so. And it will do this not only positively but negatively. For the study of the characteristics of correct thought involves the apprehension of the various forms of error to which thought is liable. Against these one is more likely to be on one's guard when one knows their nature than when one does not. Moreover, a study of logic makes it easier not only to suspect the existence of error but to recognize its exact character. Logic will, then, help the teacher both to avoid inaccurate thought himself and to correct any such inaccuracy in his pupils by making evident to them the source of the error. And this is very necessary, for owing to the limitations of their experience and knowledge, children are prone to make very rash inferences.

Nor have we in all this a reference only to the intellectual side of education. The universe which a child must learn to understand is a social and a moral universe as well as a physical one ; the facts of experience with which he starts are found in his relations to his fellows as well as in those of the material world. In these facts, too, he must find laws, and through laws he must pass to the conception of that moral system, in which alone he can find the true freedom of rational and self-realizing activity. Clearly to conceive a purpose and intelligently to adapt means to its attainment, to weigh the evidence for and against a line of conduct, are mental activities which have a direct reference to the moral life. Indeed, to separate intellectual from moral training is to hinder and not advance that true development of the pupil which it is the function of the educator to promote. For, as Mrs. Bryant says : " True development is the development of that mind, which is set, throughout, on the attainment,

in its world, of those objects which it takes to be right, and on the understanding of that world so that it may be sure of their rightness. In such development it realizes freedom and wisdom for itself, and furthers the like realization by others.”¹

Logic, then, has a bearing on the whole educational process, so far as that process is rational. But the educator must not expect detailed guidance in his work from logic any more than from psychology. Both sciences give general guidance only. Psychology investigates the forms of actual mental activity common amongst men and children, and, therefore, a study of psychology aids the educator by suggesting to him the best ways of awakening such activity. Logic, on the other hand, is regulative, and helps the educator to determine the general lines on which such activity should proceed to attain the goal of knowledge. By the character of his teaching the teacher largely determines the character of the thought-processes in his pupils. If the former is unmethodical and ill-arranged, if it permits invalid inferences, or encourages rash and unwarranted conclusions, then the pupils will not be helped to think clearly and accurately, but will rather be hindered from doing so. But if, on the other hand, the teacher's presentation of every subject is well-arranged, if his inferences are not only just but shown to be just, if the importance of weighing evidence is insisted on, and no conclusions accepted which the evidence at hand does not warrant, then the pupils are being unconsciously trained to habits of accurate thought. Thus all teaching should be ‘logical’ in the sense that it should be the expression of methodical and valid thought.

But the subject-matter of the thought, and the

¹ *Educational Ends*, p. 290.

consequent character of the knowledge gained by the pupils can be determined neither by psychology nor by logic. As we saw in an earlier chapter, logic examines into the general nature of the processes by which knowledge is attained. Whether the general conditions of knowledge thus brought to light are fulfilled in any particular case must be left to the special science in question to determine. Similarly, the particular details of logical arrangement in any piece of teaching cannot be decided by an appeal to logic alone. Logic warns us to insist on sufficient evidence; but logic alone cannot decide when the evidence is sufficient. From it we gather the general conditions of sufficiency, but other knowledge must determine how far those conditions are fulfilled. Hence, logic, like psychology, gives only the broad, general, and abstract bases of educational method. But the guidance thus supplied may at least help us to avoid the somewhat sweeping criticism of Ruskin that "Modern 'education' for the most part signifies giving people the faculty of thinking wrong on every conceivable subject of importance to them."¹

§ 2.—The first point which logic emphasizes in educational theory is that all true education must be relative to the society in which it is given. It is an error far too common to consider education exclusively from the point of view of the individual child. But a child is not merely an individual. He is equally a member of a social organism, and into the life of that organism he is born as surely as he is born to his own individual life. Indeed, he is an individual only because he is a member of the social organism, and, therefore, his true individuality is expressed, and his true nature realized, so far, and so far only, as he

Education
Relative to
Society.

¹ *Sesame and Lilies*, p. 38.

shares the common organic life. Education has to prepare him to live his life in a society which has attained a certain stage of civilization and knowledge. It cannot do this by ignoring these factors. Hence it is evident that we may be led very far wrong if we adopt as more than the broadest of general principles the maxim that "the education of the child must accord both in mode and arrangement with the education of mankind, considered historically."¹ This inference from the general parallelism between the development of the individual and that of the race has been a favourite principle with many educators since the time of Pestalozzi. And it is true that "in the education of the mind of the race, as in that of the individual, each different age and purpose requires different objects and different means; though all dictated by the same principle, tending towards the same end, and forming consecutive parts of the same method."² But to carry the principle so far as to find the only suitable material for the nourishment of the youthful mind in the intellectual products of the childhood of the race is to ignore many most important facts. As the modern child is a member of a very different social organism from that in which his savage ancestors lived, so his mental life is different from theirs. He finds all around him a different way of interpreting the facts of experience, different views of what is right and what is wrong, different conceptions of life and duty. All these he insensibly absorbs, for he learns to think and talk in a language which enshrines them all, and they profoundly modify the development of his mind. Though the products of primitive times, therefore, appeal to one factor of his

¹ Spencer, *Education*, p. 67.

² Coleridge, *The Friend*, vol. iii., pp. 180—181.

individuality, they appeal to one only, and, as a consequence, they are not fitted to supply all the mental nourishment which he requires. In many cases, indeed, expressing as they do a stage of morality which was, in many points of practice, actually antagonistic to our own, they are quite unsuitable for leading a child to a comprehension of the morality which we desire him to learn to live. Such a misreading of the task of education is the result of ignoring the bearing of logic on educational theory and practice and basing both on an individualistic psychology. So we are continually told that education means development. It does, but it means something more. Education is not mere development, it is training; and training implies an end clearly conceived by the trainer, and means carefully organized to attain that end. The child is much too immature to understand what he should aim at being, or consistently to pursue his purpose if he could conceive it. The educator's task is to assist in producing that which the child would wish to develop for himself had he a clear idea of his own nature, but which he will never reach if left to himself. It is this external and universal aspect of education which the reference to logic emphasizes.

This aspect is seen on the intellectual as much as on the moral side of the educational process. Here we must take as our axiom that knowledge exists, that laws and theories have been proved and shown to be true. This proof has been a process going on throughout the ages. With many a wandering by the way men have come in many cases to recognize the true connexion between the evidence they have and the conclusions which may be drawn from it. The child must also be led gradually to appreciate the force of this same evidence. But his process is a more

direct one, for it is along a path determined for him by his teacher. He escapes the wanderings, but he follows the same general route. In this sense his development is parallel with that of the race, and the teaching is on historical lines. But there is another element. In the determination of the objects studied, in the arrangement of the stages of study, in the use of scientific apparatus of various kinds, we have that element of appeal to authority which can never be absent from education. For in all these we have the immature child accepting with unquestioning faith the results of much slow mental work on the part of others. The child, for example, does not question the accuracy of his microscope, but the microscope embodies much knowledge of physical laws; these laws, in using the microscope, the child accepts on authority. Only so can he enter into the heritage of knowledge to which he is born.

Method and
Self-
Activity.

§ 3.—The next great lesson that logic, equally with psychology, teaches the educator is that the attainment of knowledge is the result of mental exertion. To educate is to train to think, for by active thinking alone is knowledge attained. Without active thought we cannot get beyond mere belief, for to pass from belief to knowledge means to sift and weigh evidence for oneself. This was clearly seen by Plato, and has been frequently insisted on by later philosophers, but it has been yet more frequently forgotten. "Alas!" says Coleridge, "how many examples are now present to my memory, of young men the most anxiously and expensively be-school-mastered, be-tutored, be-lectured, anything but educated; who have received arms and ammunition, instead of skill, strength, and courage; varnished rather than polished; perilously over-civilized, and most pitiably uncultivated! And all from inattention

to the method dictated by nature herself, to the simple truth, that as the forms in all organized existence, so must all true and living knowledge proceed from within ; that it may be trained, supported, fed, excited, but can never be infused or impressed." ¹ The educator can no more think or learn for the pupil than he can breathe or eat for him, and true teaching is leading another to think and to learn.

It follows as a corollary from this that there can be no one mechanical method of teaching such as was dreamt of by Pestalozzi when he wrote : " I believe it is not possible for common popular instruction to advance a step, so long as formulas of instruction are not found which make the teacher, at least in the elementary stages of knowledge, merely the mechanical tool of a method, the result of which springs from the nature of the formulas and not from the skill of the man who uses it." ²

Method not
Mechanical.

This neglects the fact that education has always an individual aspect, as it deals with the development of particular children. There is no child in general, but children differ from each other both generically and specifically. They differ generically according to their nationality. A German child is different in many points from an English child, and both from a French child. To dream, then, that a system or method of education which has been found successful in one nation can be profitably transplanted without very serious, and indeed radical, modifications, into another, is to fall into a very dangerous mistake, and one which, if put into practice, is calculated to do most serious mischief. Then again, classes of children belonging to

¹ *Op. cit.*, vol. iii., p. 174.

² *How Gertrude Teaches her Children*, trans. by Holland and Turner, p. 41.

the same nationality differ according to their social surroundings, and lastly, individuals brought up in very similar surroundings differ in natural disposition and endowment. Of all these differences true education must take account. The general system of schools in a nation must be adapted to realize the national ideal; the kind of aim and walk in life of the pupils of each school must be recognized by that school; and the personality of each child in his school must be considered by every true teacher. Hence, it is obvious that the skill of the teacher can never be replaced by any formulas of method.

Still more paradoxical was the saying of Jacotot that with a true method "every one can teach; and, moreover, can teach that which he does not know himself."¹ Such an idea shows a fundamental misconception of the teacher's functions. He must stimulate and guide, and in instruction, as in education generally, he must clearly see the end towards which he would lead the child, and the path which must be followed. He must himself be in possession of a system of knowledge before he can help his pupils to grasp that system. No doubt he must be able to place himself at the child's starting-point, but he must see the end of the process at the same time as the beginning, with a clearness of which the child is incapable. Pestalozzi saw only the first half of this truth when he wrote of his experiences at Stanz: "I could neither write, count, nor read perfectly . . . and really my ignorance of all these things was essentially necessary, in order to bring me to the highest simplicity of methods of teaching."² As method means ordered progress towards a definite end, it is obvious that one who knows

¹ Quoted by Quick, *Educational Reformers*, p. 417.

² *Op. cit.*, p. 22.

not the end cannot with certainty determine the method.

§ 4.—The conception of education as relative to the mental life of society gives us, however, that broad guidance as to method which is all that educational theory can supply.

Educational
Method
Relative to
Current
Conception
of Know-
ledge.

In the Middle Ages, when the conception of the process of knowledge was confined to deductive inference from general judgments universally accepted as true, the methods of teaching naturally followed the same lines. General principles were enunciated by authority, and formed the foundation of the whole process. It is a mistake to suppose, however, that this made the development of the self-activity of the pupil an impossibility. It simply determined the direction which that activity should take. No doubt there was much merely mechanical teaching then as now, but no one who is acquainted with the subtleties of the scholastic logicians can say that they possessed inactive minds. The mediæval theory of teaching was in relation to the current conception of the method of knowledge, and the practice was a more or less adequate carrying out of that theory.

With the growth of modern science men's conception of the method of knowledge has been considerably modified. The demand for direct evidence has replaced the appeal to authority as the basis of knowledge, and as a consequence, the inductive method has been largely substituted for the deductive. This change has affected educational practice somewhat slowly, and the traditional methods of mediævalism still linger amongst us. But they linger only as corpses, for unless the methods of education are in harmony with the current conceptions of the method of knowledge, they have no life in them, and the

Heuristic
Methods.

school fails to fulfil its true function in the social organism. To attain this harmony the pupil must be set to seek knowledge for himself by analysing his experiences. Hence arise what are known as 'heuristic' methods of teaching, that is, "methods which involve our placing students as far as possible in the attitude of the discoverer—methods which involve their *finding out*, instead of being merely told about things."¹

The employment of such methods is not mainly a question of subjects. They are doubtless appropriate in the physical and natural sciences, but they are equally applicable to mathematics and the humanities. A boy who has by his own efforts solved a problem in geometry has made a discovery quite as surely as one who has worked an experiment in physics or chemistry and drawn an inference from it. So a pupil who has exerted his intelligence on a piece of Latin prose or an English Essay, who has sorted and arranged his ideas, who has compared and weighed different modes of expressing his thoughts, has been engaged in an original investigation both into the subject matter of his theme, and into appropriate means of expressing it. Nor can it be denied that a pupil who has worked out for himself a topic in history, comparing and weighing authorities in the school library, has been engaged on a true voyage of discovery. The essence of heuristic methods is that the pupil learns to think for himself, not that he learns to do certain things with his hands, though that, too, may be involved. There is nothing of the heuristic method, for example, if a pupil in a chemical or physical laboratory works 'experiments' which have been dictated to him by his

¹ Armstrong, *The Heuristic Method of Teaching in Special Reports on Educational Subjects*, vol. ii., p. 390.

teacher. To him they are not experiments at all, for the essence of experiment is the mental planning of what is to be done and the clear conception of why it is worth doing. If, on the other hand, the pupil does this mental part of the work, it is comparatively unimportant who carries out the actual physical manipulation.

The demand for heuristic methods, then, is not a demand for a mainly 'scientific' course of study. "Sense-impression of Nature," said Pestalozzi, "is the only true foundation of human instruction, because it is the only true foundation of human knowledge,"¹ and quite a school of educators tell us the same thing. But unless a quite unjustifiable extension be given to the words "sense-impression of Nature," the premise is not true. Human experience is not limited to sense-impressions of the material world, but includes all kinds of social experiences as well, and to exclude all consideration of these latter from any stage of education is to ensure an imperfect development of the humanity of the pupil.

§ 5.—Educational method must, then, be an active process on the part of the pupil, and must show the general characteristics of definiteness of starting-point and of aim, and of orderly arrangement of means, which we saw in chapter viii were the essential marks of methodical thought. But here we see at once that there must be a material difference between the procedure of the original discoverer and that of the pupil in school. The discoverer comes to his task with abundant knowledge which guides him in selecting the material he will study, in concentrating attention on this or that aspect of the selected facts and disregarding the rest, in forming hypotheses,

Method of
Science and
Method of
Education.

¹ *Op. cit.*, p. 200.

and in inventing modes of testing such hypotheses. The school-boy is in a very different plight. But we saw that without such preliminary knowledge all advance in knowledge is impossible. It follows that the teacher must supply it, and the distinction between good and bad teaching is in the manner in which this is done. The bad teacher tells the pupil certain facts and directs him to do this or that to illustrate those facts. The good teacher supplies the required knowledge by simply selecting and arranging the facts so that this great preliminary difficulty is overcome, and then setting the pupil to work on those facts by himself. "It is needless to say," writes Professor Armstrong, "young scholars cannot be expected to find out everything themselves; but the facts must always be so presented to them that the process by which results are obtained is made sufficiently clear, as well as the methods by which any conclusions based on the facts are deduced."¹

The essence of good teaching is that it forms accurate and methodical habits of thought. But, as we have seen, methodical thought is emphatically thought of relations and of system. "The absence of method, which characterizes the uneducated, is occasioned by an habitual submission of the understanding to mere events and images as such, and independent of any power in the mind to classify and appropriate them. The general accompaniments of time and place are the only relations which persons of this class appear to regard in their statements. As this constitutes their leading feature, the contrary excellence, as distinguishing the well-educated man, must be referred to the contrary habit. Method, therefore, becomes natural to the mind which has been accustomed to contemplate not things only, or for their

¹ *Op. cit.*, p. 401.

own sake alone, but likewise and chiefly the relations of things, either their relations to each other, or to the observer, or to the state and apprehension of the hearers." ¹

This apprehension of relations, as we have seen, is the work of thought upon the elements which result from analysis of experience. But we have also seen that it is work of the most extreme difficulty, and one requiring the most careful sifting of evidence. The caution which marks the scientific discoverer is, however, far from being a prominent feature of the mental activity of childhood. Nothing is more characteristic of the untrained mind than the rashness with which it jumps to conclusions upon utterly insufficient evidence. The tendency to generalize every observed relation is natural to the human mind, and is both guided and prompted by the use of language. A class of children after seeing two or three examples of the expansion of metals by heat, frequently rushes to the conclusion that all metals, or even all solids, expand under the action of heat. And too often the teacher accepts such a generalization as, with a few exceptions, a valid inference. To do this may be to teach 'science,' but it most certainly is not to teach scientifically. It is, indeed, to cultivate that habit of rashness in drawing conclusions, and that inability to estimate the force of evidence which it is the special task of education to replace by the very opposite qualities. The evidence in the supposititious case we have taken will not even justify the assertion that those metals which the children have just seen expand under heat will do so under all conditions of initial temperature. The generalization suggested is only the first wild guess of the

¹ Coleridge, *op. cit.*, pp. 107—108.

untrained mind ; to treat it as a valid inference is to introduce utter confusion into all conception of scientific method. Mr. Herbert Spencer objects to the teaching of languages, because he thinks they encourage dogmatism on the part of the teacher. It is to be feared that much of the 'science teaching' in schools encourages dogmatism on the part of the pupils, and one may be allowed to think that the dogmatism of ignorance is worse than that of knowledge. As Mrs. Bryant well says, "the mind which is active needs also to be docile."¹

Nor is dogmatism on the part of the teacher by any means absent from the ordinary lesson in science. In very many cases the evidence which can be offered to a class of children in support of a law in natural or physical science is necessarily insufficient to establish that law. As a result, the law is guessed at by the children, and either their guess is accepted as a valid inference from the facts observed, or the teacher rightly treats the guess as nothing but a guess, and then tells his pupils dogmatically that the guess is known to be a true one by evidence which they cannot comprehend. This latter course is certainly preferable to the former, for the very essence of a good method is to mark exactly how far the evidence offered will justify the mind in going. The question for inference is not the scope or accuracy of the conclusion, but the sufficiency of the evidence on which that conclusion is based. One of the chief advantages derived from the teaching of natural or physical science should be the recognition by the pupils of the difficulty of arriving at truth, and of the need of caution in making inferences from insufficient evidence. It must still be to mathematics and

¹ *Educational Ends*, p. 265.

languages that the teacher must turn when he wishes to train his pupils in drawing conclusions which are demonstrably certain, for in those subjects only is it generally possible for the youthful mind to grasp all the evidence necessary to establish a proposition as a demonstrated truth. It is, as we have said, in helping a teacher to distinguish between good and bad inferences, to estimate when the evidence grasped by the mind of his pupils justifies a certain conclusion, when one only more or less probable, and when it merely suggests a possible line of enquiry, that a study of logic has the most practical bearing on education.

§ 6.—It is evident then, that the method of knowledge as carried out by the child differs materially from that of the scientific discoverer, not only in that it is guided from without by one to whom the whole process and the end to be attained are familiar beforehand, but also in its want of both exactness and depth. These are characteristics which can only come with increased knowledge and power of insight, just as the power to work alone can only be developed gradually out of work under guidance which little by little decreases in amount. But that the power of working alone may be developed, it is essential that the whole process should be carried out. Hence the pupil must be taken through inductive processes similar to those described in the preceding chapters. He must begin by analysis of facts and end with system. If he stops anywhere on the way we have a case of arrested development. The danger of this, it is to be feared, is not sufficiently recognized, and therefore, not adequately guarded against. With the insistence on the training of sense-observation, which is so fashionable at the present day, there is

Maxims of
Method.

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some danger that the purely instrumental and preliminary character of such observation may be lost sight of, and that the child may remain in the very first stage of knowledge. Even when this danger is avoided there remains that of arrest in the second stage of abstract law. "Proceed from the concrete to the abstract," says a favourite maxim of the educational text-books. But this is only half the process. The mind should not rest in the abstract, but having found abstract relations in the concrete facts of experience, it should not only understand those facts better, but should also have a key to the understanding of many other concrete facts. With the concrete we should begin, and with the concrete we should end.

But the concrete with which we start is vaguely apprehended as a whole which seems simple to us, because our minds have not analysed it and found that its elements are many and complex. On the other hand, the concrete with which we end is one definitely and clearly grasped, because the combined processes of analysis and synthesis through which the mind has passed have shown it to us as a complex whole of inter-related elements. It is this development of the concrete idea which seems to be intended by those other common maxims, "Proceed from the indefinite to the definite," and "Proceed from the simple to the complex."

It will be seen that these last two maxims refer primarily to the kinds of ideas we have of things at the beginning and at the end of a process of acquiring knowledge. Much mistaken teaching has been based upon an application of the latter of them to the arrangement of the material of instruction. For in the case of the matter of knowledge, the "simple" are the ultimate and abstract elements and

relations which we reach at the end of a process of analysis, whilst the "complex" is the whole piece of experience with which that analysis starts. Thus interpreted, this maxim is in contradiction to the correlative one which tells us to begin with the concrete and go on to the abstract.

A similar correlate to the maxim "Proceed from the indefinite to the definite" is that which tells us to "Proceed from the known to the unknown." As the former refers primarily to the organization of the contents of the pupil's mind, so the latter deals with the arrangement of the subject-matter by which that organization is carried out. Looked at from the side of the contents of the mind, the procedure is from the unknown to the known; for that which is indefinite is very imperfectly known, whilst what is truly known is definite.

It is seen, then, that these commonly accepted maxims must be taken in connexion with each other and woven into a system in order that each may bear its proper force, and that they are none of them really fundamental principles of method. It may be noted, too, that the form in which they are commonly expressed, "Proceed from . . . to . . .," is liable to misunderstanding. The words suggest a false view of knowledge as consisting of disconnected chains of ideas bound together by various bonds of association. When I "proceed from" Leeds "to" London, I leave the former, and pass many intermediate places before I reach the latter. But the true development of knowledge does not correspond to any such serial arrangement. Its end is, as we have seen, system, and the words "proceed from . . . to . . ." must, therefore, be understood as implying merely that there should be a mental process on the part of the learner, not that he should leave his starting-point in attain-

ing his end. In true system, starting-point and end have become organic parts of one whole construction.

Rightly and fully understood, the maxim "Proceed from the empirical to the rational" is more fundamental than any we have considered, for the "empirical" are the facts of experience of all kinds, and the "rational" is that ultimate system in which alone explanation is found. In making explicit the method by which this advance can be made, logic renders its greatest service to educational theory. For the possibility of arrested development of which we have spoken is the greatest danger to which education is liable. "The good observer . . . may not have gone far enough to make him more than a good observer; he may have been stopped by the difficulties of abstract attention in clear judgment, or his thirst for knowledge in its true form of complete unification may have failed him later on. This latter case is, perhaps, not uncommon."¹ Dr. Harris expresses the same fear: "It is believed that arrested development of the higher mental and moral faculties is caused in many cases by the school. The habit of teaching with too much thoroughness and too long-continued drill the semi-mechanical branches of study, such as arithmetic, spelling, the discrimination of colours, the observation of surface and solid forms, and even the distinctions of formal grammar, often leaves the pupil fixed in lower stages of growth and unable to exercise the higher functions of thought."² It is only when teachers clearly apprehend the existence of this danger, and understand how knowledge develops from the lowest stage to the highest that our schools will do the work the country has the right to require of them, for only then will they make

¹ Bryant, *Op. cit.*, p. 231.

² *The Psychologic Foundations of Education*, pp. 6—7.

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the most and the best of the rising generation. And it is only by making the most and the best of any individual that we can thoroughly fit him to do the most and the best for the community whose corporate life he shares. For the nobler, wiser, and more skilful a man is, the more fully and perfectly will he fulfil those functions which the actual circumstances of his life set before him, which the community demands as his duties, and which he will himself delight to render, just because, being wise and good, he has truly conceived his place and function in that system of the universe of which he forms an integral part.

EXERCISES IN INFERENCE

Analyse the following inferences, determine their nature, and estimate their validity—

1. All these boys are both mischievous and clever ; therefore cleverness and a love of mischief go together.

2. A prudent man avoids catching cold ; a man cannot be a successful merchant unless he is prudent ; therefore all successful merchants avoid catching cold.

3. To say that every rule has an exception is to talk nonsense, for as the assertion sets up to be a rule, it contradicts itself.

4. " If thou wert never at court, thou never sawest good manners ; if thou never sawest good manners, then thy manners must be wicked ; and wickedness is sin, and sin is damnation. Thou art in a parlous state, shepherd."—Shakespeare : *As you like it*, Act iii., sc. ii.

5. If all prophets spoke the truth some would be believed ; therefore as none are believed it is certain none speak the truth.

6. If boys were always found out and punished when they did wrong they would cease to offend ;

therefore, the fact that boys do not invariably do what is right proves that punishment does not always follow their offences.

7. A is never found without B, and B is never found without C ; therefore C is never found without A.

8. Brighton is south of London, and Exeter is west of Brighton ; therefore London is north-east of Exeter.

9. I don't believe it, for I saw it in a newspaper, and newspapers are always telling lies.

10. Jones must succeed in the world, for he is an honest man, and dishonest people never prosper.

11. If a man has been properly taught he can teach, for experience is all that is wanted in teaching.

12. "When a fact is supported by no more than the statement of a single man, however honest he may be, historians ought not to assert it, but to do as men of science do—give the reference (Thucydides states, Cæsar says that . . .) ; this is all they have a right to affirm."—Langlois and Seignobos, *Introduction to the Study of History*, p. 197.

13. "If our printed books, after the successive revisions of author and printer's reader, are still but imperfect reproductions, it is only to be expected that ancient documents, copied and recopied as they have been for centuries with very little care, and exposed at every fresh transcription to new risks of alteration, should have reached us full of inaccuracies."—*Ibid.*, p. 73.

14. "The Rev. Hilderic Friend vouches for the genuineness of the following story : . . . 'In the village of S—, near Hastings, there lived a couple who had named their first-born girl Helen. The child sickened and died, and when another daughter

was born, she was named after her dead sister. But she also died, and on the birth of a third daughter the cherished name was repeated. This third Helen died, "and no wonder," the neighbours said; "it was because the parents had used the first child's name for the others."—"Clodd, *Tom Tit Tot*, p. 137.

15. "In all unhealthy countries the greatest risk [of fever] is run by sleeping on shore. Is this owing to the state of the body during sleep, or to a greater abundance of miasma at such times? It appears certain that those who stay on board a vessel, though anchored at only a short distance from the coast, generally suffer less than those actually on shore."—Darwin, *Journal of Voyage of H.M.S. Beagle*, p. 441.

16. "I find that a certain plant always grows luxuriantly on a particular kind of soil; if my experience of the other conditions be sufficiently various, I am justified in concluding that the soil probably possesses certain chemical constituents which are peculiarly favourable to the production of the plant."—Fowler, *Inductive Logic*, p. 139.

17. "Publius Nigidius Figulus [was] a Roman of the time of Julius Cæsar whom Lucan mentions as a celebrated astrologer. It is said, that when an opponent of the art urged as an objection the different fates of persons born in two successive instants, Nigidius bade him make two contiguous marks on a potter's wheel, which was revolving rapidly near them. On stopping the wheel, the two marks were found to be really far removed from each other."—Whewell, *History of the Inductive Sciences*, vol. i., p. 226.

18. "The only proof capable of being given that an object is visible, is that people actually see it.

The only proof that a sound is audible, is that people hear it : and so of the other sources of our experience. In like manner, I apprehend, the sole evidence it is possible to produce that anything is desirable, is that people do actually desire it."—Mill, *Utilitarianism*, pp. 52-3.

19. "Scheiner [one of the discoverers of the spots on the sun] was a monk ; and on communicating to the superior of his order the account of the spots, received in reply from that learned father a solemn admonition against such heretical notions :—‘ I have searched through Aristotle,’ he said, ‘ and can find nothing of the kind mentioned : be assured, therefore, that it is a deception of your senses, or of your glasses.’ ”—Baden Powell, *History of Natural Philosophy*, p. 171.

20. "When the palace of Nicomedia, and even the bedchamber of Diocletian, having been on fire twice within fifteen days, the people entirely refused to believe that it could be the result of accident."—Jevons, *The Principles of Science*, p. 264.

21. "A person might suppose that the peculiar colours of mother-of-pearl were due to the chemical qualities of the substance. Much trouble might have been spent in following out that notion by comparing the chemical qualities of various iridescent substances. But Brewster accidentally took an impression from a piece of mother-of-pearl in a cement of resin and bees'-wax, and finding the colours repeated upon the surface of the wax, he proceeded to take other impressions in balsam, fusible metal, lead, gum arabic, isinglass, &c., and always found the iridescent colours the same. He thus proved that the chemical nature of the substance is a matter of indifference, and that the form of the surface is

the real condition of such colours."—Jevons, *The Principles of Science*, p. 419.

22. "Aristotle, the greatest naturalist of Greece, had observed that it was a curious fact, that on the sea-shore no animal ever dies except during the ebbing of the tide. Several centuries later, Pliny, the greatest naturalist of an empire that was washed by many tidal seas, directed his attention to this statement. He declared that, after careful observations which had been made in Gaul, it had been found to be inaccurate, for what Aristotle stated of all animals, was in fact only true of man. It was in 1727 and the two following years, that scientific observations made at Rochefort and at Brest finally dissipated the delusion."—Lecky, *History of European Morals*, vol. i., p. 394.

23. "Baron Zach received a letter from Pons, a successful finder of comets, complaining that for a certain period he had found no comets, though he had searched diligently. Zach, a man of much sly humour, told him that no spots had been seen on the sun for about the same time—which was true—and assured him that when the spots came back, the comets would come with them. Some time after he got a letter from Pons, who informed him, with great satisfaction, that he was quite right, that very large spots had appeared on the sun, and that he had found a fine comet soon after."—De Morgan, *Budget of Paradoxes*, p. 279.

24. "No reason can be given why the general happiness is desirable, except that each person, so far as he believes it to be attainable, desires his own happiness. This, however, being a fact, we have not only all the proof which the case admits of, but all which it is possible to require, that happiness is a

good : that each person's happiness is a good to that person, and the general happiness, therefore, a good to the aggregate of all persons."—Mill, *Utilitarianism*, p. 53.

25. "*Nature is uniform in all its operations.* For instance, the production of all birds, and, indeed, of all living creatures, resembles that of any single bird which you may choose. It is only in the minor details that there are differences

Differences of method, therefore, confuse the young, and make their studies distasteful to them . . .

Henceforth, therefore,

(i) The same method of instruction must be used for all the sciences, the same for all the arts, and the same for all languages.

(ii) In each school the same arrangement and treatment should be adopted for all studies.

(iii) The class-books for each subject should, as far as is possible, be of the same edition."—Comenius, *The Great Didactic*, tr. Keatinge, pp. 292-3.

26. "Pigeons and doves offer a very curious case of the protection of exposed eggs. They usually build very slight and loose nests of sticks and twigs, so open that light can be seen through them from below, while they are generally well concealed by foliage above. Their eggs are white and shining ; yet it is a difficult matter to discover, from beneath, whether there are eggs in the nest or not, while they are well hidden by the thick foliage above. The Australian podargi—huge goatsuckers—build very similar nests, and their white eggs are protected in the same manner. Some large and powerful birds, as the swans, herons, pelicans, cormorants, and storks, lay white eggs in open nests ; but they keep careful watch over them, and are able to drive away intruders. On the whole, then, we see that, while white

eggs are conspicuous, and therefore especially liable to attack by egg-eating animals, they are concealed from observation in many and various ways. We may, therefore, assume that, in cases where there seems to be no such concealment, we are too ignorant of the whole of the conditions to form a correct judgment.”—Wallace, *Darwinism*, pp. 213-4.

27. “In a given state of society a certain number of persons (about 250 each year) must put an end to their own life. This is the general law, and the special question as to who shall commit the crime depends of course upon special laws, which, however, in their total action, must obey the large social law to which they are all subordinate. And the power of the larger law is so irresistible, that neither the love of life, nor the fear of another world, can avail anything towards even checking its operation.”—Buckle, *History of Civilization*, vol. i., p. 25.

28. “Some species of fresh-water shells have very wide ranges, and allied species which, on our theory, are descended from a common parent, and must have proceeded from a single source, prevail throughout the world. Their distribution at first perplexed me much, as their ova are not likely to be transported by birds; and the ova, as well as the adults, are immediately killed by sea-water. I could not even understand how some naturalized species have spread rapidly throughout the same country. But two facts, which I have observed—and many others no doubt will be discovered—throw some light on this subject. When ducks suddenly emerge from a pond covered with duck-weed, I have twice seen these little plants adhering to their backs; and it has happened to me, in removing a little duck-weed from one aquarium to another, that I have unintentionally stocked the one with fresh-water shells from the

other. But another agency is perhaps more effectual : I suspended the feet of a duck in an aquarium, where many ova of fresh-water shells were hatching ; and I found that numbers of the extremely minute and just-hatched shells crawled on the feet, and clung to them so firmly that when taken out of the water they could not be jarred off, though at a somewhat more advanced age they would voluntarily drop off. These just-hatched molluscs, though aquatic in their nature, survived on the duck's feet, in damp air, from twelve to twenty hours ; and in this length of time a duck or heron might fly at least six or seven hundred miles, and if blown across the sea to an oceanic island, or to any other distant point, would be sure to alight on a pool or rivulet. Sir Charles Lyell informs me that a *Dytiscus* has been caught with an *Ancylus* (a fresh-water shell like a limpet) firmly adhering to it ; and a water-beetle of the same family, a *Colymbetes*, once flew on board the *Beagle*, when forty-five miles distant from the nearest land ; how much farther it might have been blown by a favouring gale no one can tell."—Darwin, *Origin of Species*, pp. 344–5.

29. "Covetousness . . . being the root of all evil, should be early and carefully weeded out, and the contrary quality of a readiness to impart to others implanted. This should be encouraged by great commendation and credit, and constantly taking care that [the child] loses nothing by his *liberality*. Let all the instances he gives of such freeness be always repaid, and with interest ; and let him sensibly perceive that the kindness he shows to others is no ill husbandry for himself, but that it brings a return of kindness both from those that receive it and those who look on."—Locke, *Some Thoughts concerning Education*, § 110.

30. "If any one doubts the importance of an acquaintance with the principles of physiology, as a means to complete living, let him look around and see how many men and women he can find in middle or later life who are thoroughly well. . . . We infer that as vigorous health and its accompanying high spirits are larger elements of happiness than any other things whatever, the teaching how to maintain them is a teaching that yields in moment to none other whatever. And therefore we assert that such a course of physiology as is needful for the comprehension of its general truths, and their bearings on daily conduct, is an all-essential part of a rational education."—H. Spencer, *Education*, pp. 13, 15.

31. "That it enables a child to control its functions, and that it will be useful in after life as a groundwork for household medicine, are two reasons for teaching physiology which might, until examined, have been supposed to carry weight. The first we disallow on the ground that it is more dangerous to call attention to the functions of the body than to let them have play unobserved, while, so far as the second reason goes, we believe that medical treatment is best left to the doctors."—Dr. A. Hill, '*Physiology*,' in *Aims and Practice of Teaching*, edited by Prof. F. Spencer, p. 278.

32. "Grey, in 1729, discovered the properties of *conductors*. He found that the attraction and repulsion which appear in electric bodies are exhibited also by other bodies in contact with the electric. In this manner he found that an ivory ball, connected with a glass tube by a stick, a wire, or a packthread, attracted and repelled a feather, as the glass itself would have done. He was then led to try to extend this communication to considerable

distances, first by ascending to an upper window and hanging down his ball, and afterwards, by carrying the string horizontally supported on loops. As his success was complete in the former case, he was perplexed by failure in the latter; but when he supported the string by loops of silk instead of hempen cords, he found it again become a conductor of electricity. This he ascribed at first to the smaller thickness of the silk; which did not carry off so much of the electric virtue; but from this explanation he was again driven, by finding that wires of brass still thinner than the silk destroyed the effect. Thus Grey perceived that the efficacy of the support depended on its being silk, and he soon found other substances which answered the same purpose. The difference, in fact, depended on the supporting substance being electric, and therefore not itself a conductor; for it soon appeared from such experiments, and especially from those made by Dufay, that substances might be divided into *electrics per se*, and *non-electrics*, or *conductors*. These terms were introduced by Desaguliers, and gave a permanent currency to the results of the labours of Grey and others."—Whewell, *History of the Inductive Sciences*, vol. iii., p. 9.

33. "The publication of the quartos in 1609 gives us one limit for the date of *Troilus and Cressida*, but (i) certain discrepancies in the text, (ii) differences of style, thought, language, and metrical qualities, and (iii) important pieces of external evidence, make it almost certain that the play passed through various stages of revision, and was in all probability composed at different times."—Gollancz, *Introd. to Troilus and Cressida*, *Temple Ed.*

34. "Locke's great maxim was that we ought to reason with children. . . . Reason, apparently

a compound of all other faculties, the one latest developed, and with most difficulty, is the one proposed as agent in unfolding the faculties earliest used ! The noblest work of education is to make a reasoning man, and we expect to train a young child by making him reason ! This is beginning at the end ; this is making an instrument of a result. If children understood how to reason they would not need to be educated.”—Rousseau, *Émile* (Steeg’s Extracts translated by Worthington), p. 52.

35. “The most generally received theory [as to the origin of animal coloration] undoubtedly is that brilliancy and variety of colour are due to the direct action of light and heat ; a theory no doubt derived from the abundance of bright-coloured birds, insects, and flowers which are brought from tropical regions. There are, however, two strong arguments against this theory. . . . Bright coloration is wanting in desert animals, yet here heat and light are both at a maximum, and if these alone were the agents in the production of colour, desert animals should be the most brilliant. Again, all naturalists who have lived in tropical regions know that the proportion of bright to dull coloured species is little if any greater there than in the temperate zone, while there are many tropical groups in which bright colours are almost entirely unknown. . . . Again, there are many families of birds which spread over the whole world, temperate and tropical, and among these the tropical species rarely present any exceptional brilliancy of colour. . . . The same general facts are found to prevail among insects. Although tropical insects present some of the most gorgeous coloration in the whole realm of nature, yet there are thousands and tens of thousands of species which are as dull coloured as any in our cloudy land.

. . . The various facts which have now been briefly noticed are sufficient to indicate that the light and heat of the sun are not the direct causes of the colours of animals, although they may favour the production of colour, when, as in tropical regions, the persistent high temperature favours the development of the maximum of life."—Wallace, *Darwinism*, pp. 193–5.

36. "It may be laid down as a fundamental proposition that a wise nation will not subsidize institutions which might be self-supporting. . . . All instruction which is obviously conducive to eventually earning money can be left to take care of itself; there is no occasion whatever to subsidize technical instruction, except so far as capital expenditure is concerned, in any sense of the phrase, because as soon as any proficiency is seen to be likely to earn money, people will willingly pay to enable their children to acquire it." "So long as there are skilled workmen to be found, it is of no advantage to the State that they should be the children of persons who could not afford, or were unwilling to pay for their instruction."—Tarver, *The Debateable Land*, pp. 64, 73, 71.

37. "At Erith, in 1864, there occurred a tremendous explosion of a powder magazine. The village of Erith was some miles distant from the magazine, but in nearly all cases the windows were shattered; and it was noticeable that the windows turned away from the origin of the explosion suffered almost as much as those which faced it. Lead sashes were employed in Erith church; and these, being in some degree flexible, enabled the windows to yield to pressure without much fracture of glass. Every window in the church, front and back, was bent *inwards*. In fact, as the sound-wave reached the church, it separated

right and left, and, for a moment, the edifice was clasped by a girdle of intensely compressed air, which forced all its windows inwards. After compression, the air in the church no doubt dilated, and tended to restore the windows to their first condition. The bending in of the windows, however, produced but a small condensation of the whole mass of air within the church; the force of the recoil was, therefore, feeble in comparison with the force of impact, and insufficient to undo what the latter had accomplished.”—Tyndall, *On Sound*, p. 23.

38. “By our various physical sensations and desires, Nature has insured a tolerable conformity to the chief requirements. Fortunately for us, want of food, great heat, extreme cold, produce promptings too peremptory to be disregarded. And would men habitually obey these and all like promptings when less strong, comparatively few evils would arise. If fatigue of body or brain were in every case followed by desistance; if the oppression produced by a close atmosphere always led to ventilation; if there were no eating without hunger, or drinking without thirst; then would the system be but seldom out of working order. But so profound an ignorance is there of the laws of life, that men do not even know that their sensations are their natural guides, and (when not rendered morbid by long continued disobedience) their trustworthy guides. So that though, to speak teleologically, Nature has provided efficient safeguards to health, lack of knowledge makes them in a great measure useless.”—H. Spencer, *Education*, p. 13.

39. “When a child falls, or runs its head against the table, it suffers a pain, the remembrance of which tends to make it more careful. . . . If it lays hold of the fire-bars, thrusts its hand into a candle-flame,

or spills boiling water on any part of its skin, the resulting burn or scald is a lesson not easily forgotten. . . . Now in these cases, Nature illustrates to us in the simplest way, the true theory and practice of moral discipline. . . . Observe, first, that in bodily injuries and their penalties we have misconduct and its consequences reduced to their simplest forms. Though, according to their popular acceptance, *right* and *wrong* are words scarcely applicable to actions that have none but direct bodily effects ; yet whoever considers the matter will see that such actions must be as much classifiable under these heads as any other actions. . . . Note, in the second place, the character of the punishments by which these physical transgressions are prevented. . . . They are not artificial and unnecessary inflictions of pain ; but are simply the beneficent checks to actions that are essentially at variance with bodily welfare—checks in the absence of which life would be quickly destroyed by bodily injuries. . . . Let it be further borne in mind that these painful reactions are proportionate to the transgressions. . . . And then mark, lastly, that these natural reactions which follow the child's wrong actions, are constant, direct, unhesitating, and not to be escaped. . . . Have we not here, then, the guiding principle of moral education ? . . . No unprejudiced reader will hesitate in his assent."—H. Spencer, *Education*, pp. 101–5.

40. "Rousseau thought it was best to let children incur the natural consequences of their actions. Spencer has reproduced the same theory under the name of *natural reactions*. . . . Spencer's principle has been often criticized, and not unjustly. . . . Suppose a boy is simply inattentive during the lesson. The master cannot reprove him without infringing the doctrine of natural reactions. But if a boy is

inattentive one day, and is made to suffer no inconvenience, he will be inattentive the next and the following days. A bad habit is quickly contracted, and the natural reaction is only produced when the evil is irreparable. Inattention and habitual carelessness in a boy are naturally followed by ignorance, intellectual inferiority to his hard-working school-fellows, and finally by the difficulties of life resulting from that inferiority. The injury is only felt a long time after the faults of school-life, but then it is irreparable. . . . The child who neglects his work and plays till he is tired will not feel the punishment of his moral fault by physical fatigue. . . . Cold water is agreeable when one is bathed in perspiration; the natural reaction is inflammation of the lungs. Are we to wait till it comes? In a word, a man left to the mercy of natural reactions would descend in the animal scale; he would not even live. . . . Spencer may . . . be reasonably blamed for calling the system of discipline by *natural* consequences *moral education*. These reactions only teach the children the relations of natural causality (and that, too, not always with sufficient emphasis), but they are not of a moral character."—Guyau, *Education and Heredity*, pp. 188–96.

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